

The Blast Furnace *and* Steel Plant

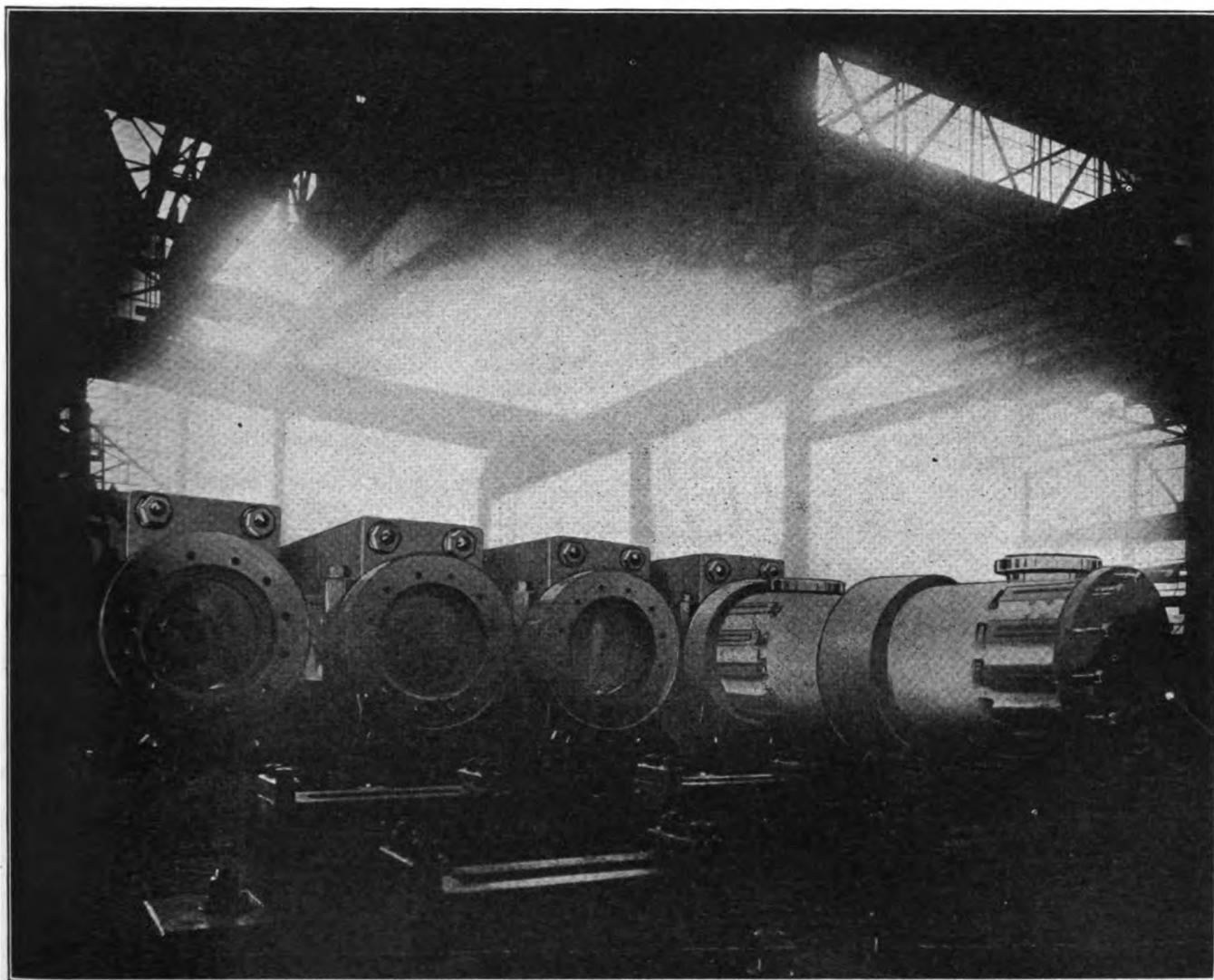
Vol. XI

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No. 6

La Belle's Giant Uniflows

13,000 H.P., 4 Cylinder 36"x60", 75 R.P.M.



The photograph shows the reversing engine, with Marshall link, during the course of erection on foundations at the La Belle plant of the Wheeling Steel Corporation.

This engine will drive the 40" Blooming Mill now building. Steam at 250 lbs., 150° superheat, supplied from a new boiler-house adjacent the blast furnaces,

will be used in this, and a duplicate engine, which, with fly-wheel addition, will drive the 19" continuous mill.

The photograph was taken shortly after the first of four cylinders was put in place, and shows the bed-plate in the foreground ready for the remaining cylinders.

Electrical Applications in Bethlehem Plant of Bethlehem Steel Company

Electrically Operated Equipment Is Most Important Factor in
High Efficiencies and Enormous Tonnages Here
Produced—Safety Emphasized Throughout

By D. M. PETTY* and A. J. STANDING†

PART I.

The Philadelphia Section of the Association of Iron and Steel Electrical Engineers recently inspected the Bethlehem Mills, and their visit was such a satisfying one, and so much enthusiasm resulted from the hospitality shown them, so many interesting things, and unusual, even to men familiar, through everyday contact, with the magnitudes of great steel plants—that it suggested the thought of publishing a complete description of electrical applications in the various departments which they saw.

To see Bethlehem means walking many miles, as a casual glance at the bird's-eye view pictured in Fig. 1 suggests. The structural mill group and yards alone, from which were shipped over 77,000 tons of "Bethlehem Beam" and other shapes during the month of April, require nearly 150 over-head cranes for their operation. Messrs. D. M. Petty and A. J. Standing, both past-Presidents of the A. I. & S. E. E., headed the entertainment committee, and with numerous aides conducted the large party through first the Lehigh and then the Saucon Divisions of the plant.

Part I is their description of the power generation and distribution features.

Part II, which follows in the July issue, will describe and illustrate the Manufacturing Departments.

POWER GENERATING STATIONS

LEHIGH DIVISION—DIRECT CURRENT STATION

A SMALL amount of electrical energy is generated as 240 volts d.c. and distributed to departments in the immediate vicinity of the power station; these are the older departments in the plant and were first to be electrified. Generating equipment in this station consists of:

- 1 625-kw., 100-rpm., 250-volt, d.c. Wood generator, direct connected to an Allis-Chalmers 30x40-in. simple steam engine.
- 1 1000-kw., 80-rpm., 250-volt, General Electric generator, direct connected to a Wisconsin 34x62x60-in. cross compound steam engine.
- 1 1200-kw., 150-rpm., 250-volt, Western Electric generator, direct connected to a Bethlehem No. 19 twin tandem 30x38-in. gas engine.
- 3 1500-kw., 150-rpm., 250-volt, General Electric generators, direct connected to a Bethlehem No. 19 twin tandem 32x42-in. gas engines.

These generators are all flat compounded and are connected to the buss through circuit breakers. The switchboard is made up of 24 1200-ampere feeder circuits and 9 2000-ampere feeder circuits. One 1500-kw. General Electric motor generator set is also connected to

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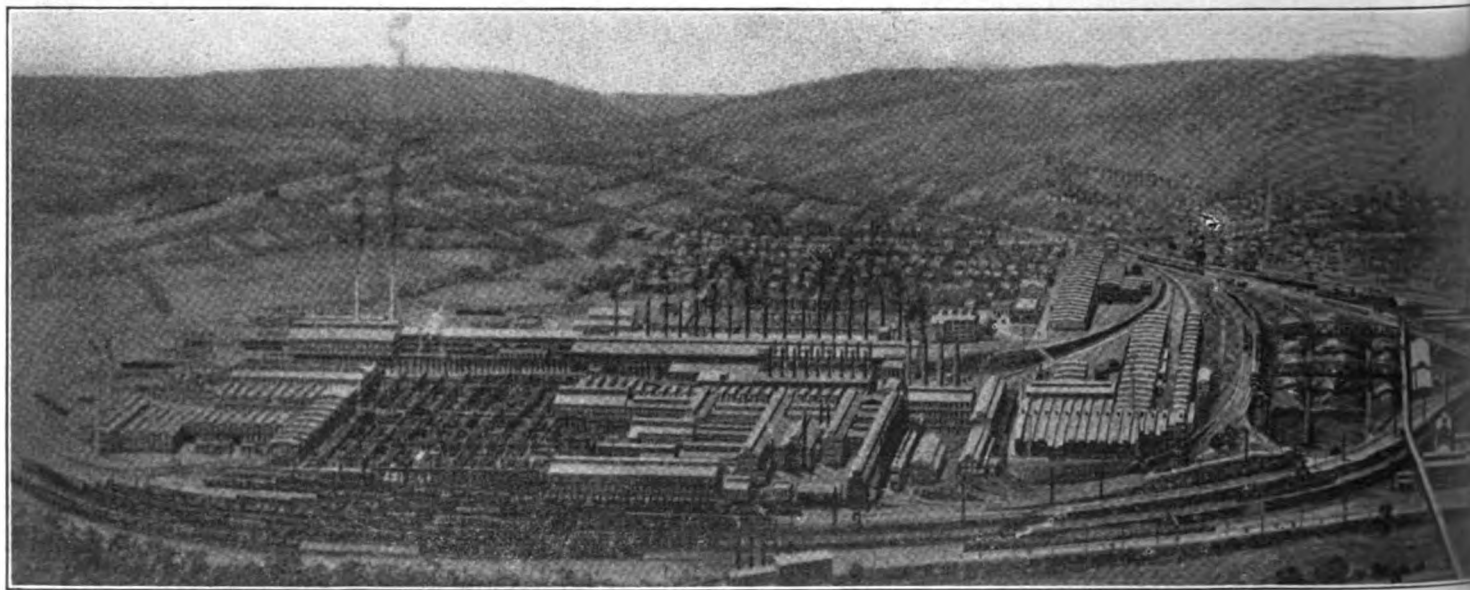


FIG. 1—GENERAL VIEW OF BETHLEHEM

Starting at left, 12-in. and 18-in. mills, No. 4 and No. 2 open hearth, shipping yards, shape mills. Center: Ore storage yards; to the left, ammunition plant No. 2, now abandoned.

this buss and serves as a tie connection with the a.c. power station. This machine can be operated either a.c. to d.c., or d.c. to a.c. Constant voltage is maintained at the buss by means of a Counter E.M.F. voltage regulator as supplied by the General Electric Company. A 2,000-ampere series booster is located in this station and is used to supply power to the ore handling yard located approximately 2,500 feet from the buss. At present this machine is held as a reserve and to facilitate a tie connection between the d.c. power station and the car dumper sub-station. There are two 25-kw. motor generator sets, 220 volts d.c. to 110 volts d.c., which supply power for the ignition system used on all of the gas engines in the plant. A storage battery is also connected to the ignition system so that in case of voltage failure on these motor generator sets ignition is taken automatically from the storage battery. This emergency circuit is carried to each engine and the switching from motor generator to battery is carried out automatically for each engine, thus providing protection against any form of interruption.

Saucon Division—Direct Current Station.

Saucon Division also has two d.c. power generating units, held primarily as reserve capacity to insure continuity of service to the Saucon hot metal departments. These were the first units installed in the Saucon Division and for a good many years were capable of supplying the entire demand. These units are now supplemented by rotary converters, which will be described more fully later. These units consist of:

- 2 1000-kw., 80-rpm., 250-volt, General Electric generators, direct connected to Wisconsin 34x62x60-in. cross compound steam engines.

Alternating Current Power Station.

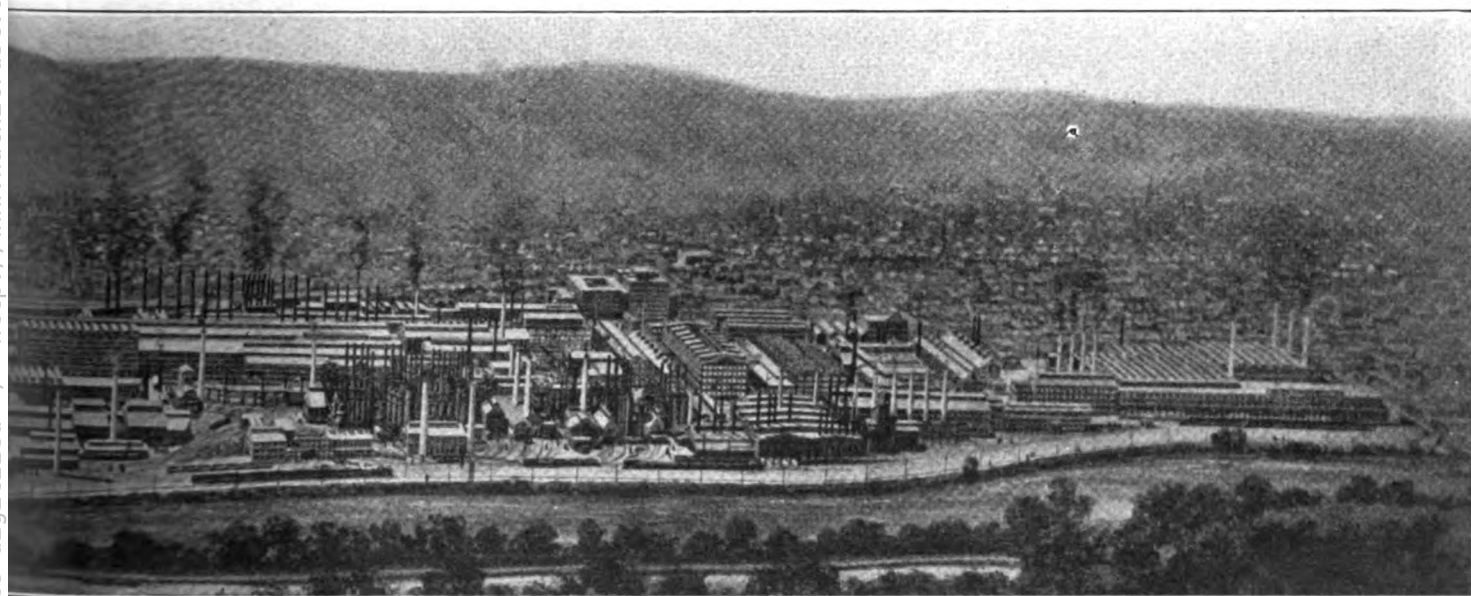
The a.c. power station is in the same building as the above mentioned Lehigh Division d.c. power station; it also houses the blowing engines for the blast furnace department. This building is located just south of the blast furnaces.

The great bulk of power used in the Bethlehem plants, both Lehigh and Saucon Divisions, is generated in this station. The generating units consist of:

- 6 2500-kw., 0.8 pf., 3-phase, 25-cycle, 6600-volt, 88.3-rpm., General Electric alternators, direct connected to Bethlehem No. 26-D twin tandem 45x60-in. gas engines.
- 1 2500-kw., 0.7 pf., 3-phase, 25-cycle, 6600-volt, 88.3-rpm., General Electric alternators, connected to No. 26-D twin tandem 47x60-in. Bethlehem gas engine.
- 1 2000-kw., 3-phase, 25-cycle, 6600-volt, 115-rpm., General Electric alternator, direct connected to a 6-cylinder Bethlehem Diesel oil engine.

These alternators are all connected to the main busses, which are in duplicate; the buss structure is built of concrete and the buss bars are separated by concrete barriers and carried in bushing type insulators. Each alternator is provided with a 600-ampere H-3, 15,000-volt General Electric oil switch with the two pots of each phase mounted in separate compartments. One spare oil switch is provided for all of the generators and may be connected to any generator by means of a transfer buss; switching to this buss is accomplished through specially designed disconnecting switches mounted in separate compartments directly beneath the compartment containing the H-3 oil switches. No overload protection is provided for the generators, but a reverse power relay serves to disconnect any generator from the buss in case of failure at any point between the oil switch and the generator. Excitation is provided at 220 volts by a 350-kw. motor generator set driven by a 6600-volt squirrel cage induction motor. A duplicate exciter is held in reserve, and in addition to this a direct connection is provided with the d.c. power station which may be used to build up voltage in starting the first alternator. Constant voltage is maintained by means of a General Electric Tirrill regulator and 6800 volts is normally maintained as the buss voltage.

The operating switchboard is located on a gallery directly above the oil switch and buss room, and totally enclosed with glass, giving the operators a full view of the engine room. Ventilation is provided in the operators' room by means of an air washing and cooling sys-



PLANTS, LEHIGH AND SAUCON DIVISIONS

To the right: Armor departments, Nos. 4 and 3 tempering departments. Reading to left, No. 2 shop, blast furnaces, machine shops, No. 4, No. 6 and No. 3 open hearth. No. 2 merchant mills at extreme right.

tem. A bank of three 500-kw. oil immersed self-cooled transformers provides 230-volt power for auxiliary motors located in the power station, also power for driving the gas scrubbers and shops in the vicinity of the station. Cooling water for the gas engines is circulated through a spray pond, by motor driven pumps. Power is supplied directly from the station buss through lead covered cable.

While running, gas engine units carry an average monthly load of 2,850 kw.

Normal operation under full load conditions is to run six engines day shift and five night shift. A more com-

These transformers are located in the Minsi Trail sub-station and feed directly into the main busses of this station.

The second connection is with the power company's 110,000-volt system. This is made through three 110,000-volt, 2500-kw., single phase, oil immersed, self-cooled radiator type General Electric transformers located at the Quarry sub-station. This sub-station is across the Lehigh River from the plant, and is of the standard outdoor type, General Electric 110,000-volt outdoor oil switches being used to provide overload protection for the transformers, all other switches being made

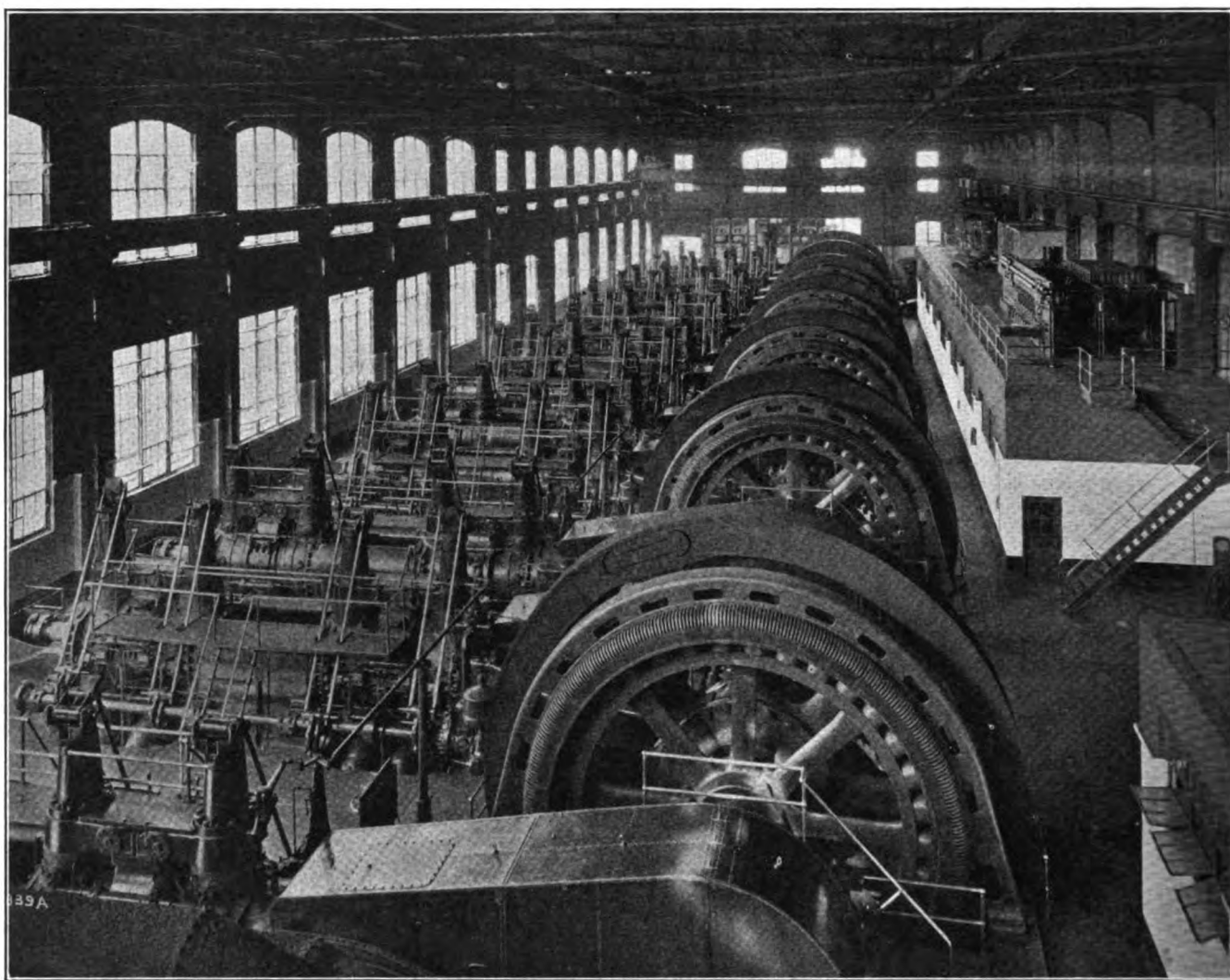


FIG. 2—Alternating current power station. Seven gas engines with Diesel oil engine in background.

plete analysis of the operating conditions and costs was given in a paper by D. M. Petty at the convention of the Association of Iron and Steel Electrical Engineers, September, 1922.

Purchased Power.

In addition to power generated, 8,500 kw. based on a three-minute demand is purchased from the Pennsylvania Power & Light Company. During the war a much larger block of power was purchased and two connections were established with the power company. The first connection was with their 22,000-volt distribution system. This connection is through three 2500-kw., single phase, oil immersed, self-cooled Pittsburgh transformers, connected Delta-Delta, secondary voltage being 6600 volts.

through hand operated disconnecting switches. The secondary voltage on these transformers is 6600 volts, which is transmitted across the river on two 250,000 circular mil. circuits, carried on towers which also carry a telferage system used in transporting the limestone from the quarry, across the river, for use in the blast furnaces. These circuits are tied together and are connected directly to the main busses in the Minsi Trail sub-station. A small amount of load is also taken from the 6600-volt circuits at the quarry, two General Electric H-3 oil switches mounted in concrete cell structures provide switching facilities at this point. In normal operation power is taken from the power company over the 110,000-volt connection. Over week ends and holidays power

is furnished to the power company through their 22,000-volt system.

Operation of Power System.

In operating the a.c. power system the gas engine station and the power company system are paralleled. This may be done at either the Minsi Trail sub-station or at the a.c. power station. Two 300,000 circular mil. overhead circuits connect the Minsi Trail sub-station and the power station. These lines may be operated independently, synchronizing being performed on the first line only. When taking power from the power company over both their 110,000 and 22,000-volt systems, no difficulty has been experienced in throwing the 6600-volt side of these transformers in parallel through the Minsi Trail busses. Under normal operation the a.c. power station load is approximately 18,000 kw.; 10,000 to 20,000 kw. of this goes out over the trunk lines west, feeding the No. 2 merchant mills and Lehigh Division departments; 1,500 kw. goes to the motor generator set in the d.c. power station, and 1,000 kw. to the transformers located in the power house. The balance, 4,000 to 6,000 kw., goes out over the tie lines to the Minsi Trail sub-station; here it is paralleled on the busses with the incoming power from the power company, to the extent of about 7,000 kw. From the Minsi Trail busses approximately 11,000 to

sub-station is connected through d.c. feeders to two departments which are also connected to the d.c. power station. In case of trouble it is always possible to handle the load in these two departments from either the sub-station or the power station. Also, in case of power failure the d.c. power station can supply a limited amount of power to the merchant mill sub-station busses, sufficient as a rule to take care of all vital loads, such as to finish pouring of a heat in Open Hearth No. 3, or other vital operations.

A similar connection is also made between the d.c. power station and the car-dumper sub-station. This can be made through the series booster mentioned above, or directly with the busses, without the booster.

The low tension a.c. distribution systems are also arranged so that the transformers located in the power house can supply a limited amount of power, in case the high tension distribution system is out of commission for any reason whatever. These connections are all made through hand operated switches, as it was not considered necessary to make this operation automatic.

Following is a tabulation showing the various transforming stations. It should be noted that wherever possible sub-stations have been located, in connection with other electrical apparatus, so that the operator could not only attend to the transforming apparatus, but also attend to the starting up of mill drives, etc.

MOTOR GENERATOR SETS

Quantity	Size	Location
3	500 KW	35-in. Mill Sub-station
1	1500 KW	Power House
1	400 KW	No. 5 Tempering Plant
1	500 KW	No. 3 Bridge Shop
1	150 KW	Redington
2	1000 KW	Car Dumper Sub-station
1	500 KW	Car Dumper Sub-station
1	300 KW	Transfer Car Set

TRANSFORMERS

Quantity	Size	Location	Primary Voltage	Secondary Voltage
2	25 KVA	Cinder Dump	6600	220
2	25 KVA	Beth. Quarry Sub-Station...	6600	220
3	25 KVA	Redington Proving Grounds	4400	220
1	25 KVA	Minsi Trail Sub-Station.....	6600	220
3	50 KVA	22-in. Mill	6600	220
3	50 KVA	Minsi Trail Sub-Station.....	6600	220
3	90 KVA	No. 3 Bridge Shop.....	6600	180
3	100 KVA	Merchant Mill Sub-Station..	6600	220
3	100 KVA	35-in. Mill	6600	220
3	100 KVA	Crucible Mills	6600	220
3	100 KVA	Steel Foundry	6600	220
3	100 KVA	Bethlehem Quarries	6600	445
3	100 KVA	Redington Fuse Plant.....	6600	220
3	100 KVA	No. 4 Foundry.....	6600	220
3	100 KVA	Power House	6600	220
3	100 KVA	Drop Forge Department....	6600	220
2	125 KVA	Redington	6600	4400
3	200 KVA	Electric Furnace and Open Hearth No. 3.....	6600	220
3	200 KVA	No. 3 Shop.....	6600	220
3	200 KVA	No. 6 Annealing Plant.....	6600	220
3	200 KVA	No. 9 Shop.....	6600	220
3	200 KVA	18-in. Mill Sub-Station.....	6600	220
3	280 KVA	Cinder Dump	6600	180
3	400 KVA	Bethlehem Quarries	6600	480
3	500 KVA	Power House	6600	220
1	500 KVA (S.P.)	Wheel Shop	6600	440
3	500 KVA	No. 2 Shop.....	6600	220
3	500 KVA	No. 5 Boiler House.....	6600	220
3	500 KVA	No. 2 Projectile Dept.....	6600	220

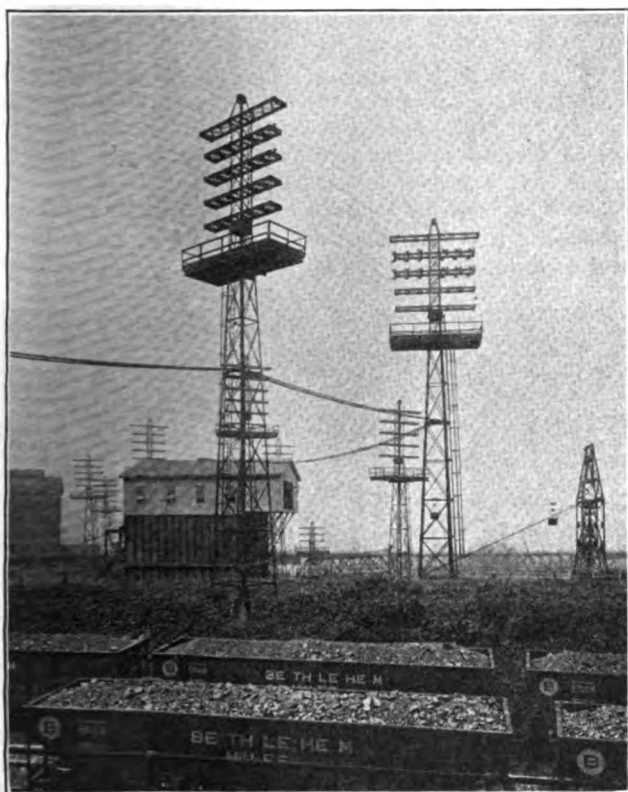


FIG. 3—Transmission towers loop system. Terminal of telerage system, showing buckets carrying limestone.

13,000 kw. go out over the loop system and is distributed to the car dumper sub-station, the Saucon power station, the Bessemer sub-station to the 12-in. and 16-in. mill sub-station, to the Saucon pumping station, and finally back to the Minsi Trail busses. A tap-off at the Bessemer sub-station supplies power to the No. 5 shop sub-station and No. 2 projectile department, the cinder dump and to Redington. All load dispatching is done from the a.c. power station switchboard gallery.

As a matter of protection the merchant mill d.c.

2	500 KVA	No. 3 Bridge Shop (connected Open Delta).....	6600	440
3	500 KVA	Bessemer Blowers	6600	220
3	2500 KVA	Minsi Trail Sub-Station.....	22000	6600
3	2500 KVA	Bethlehem Quarries	110000	6600

Distribution System.

All primary distribution of power is made at 6600 volts, 3 phase. Wherever possible more than one route is taken to deliver power to the important load centers,



FIG. 4—Car dumper sub-station. Showing loop system coming in and going out. Ore storage and bridge in background.

in order to insure continuity of service, and also to facilitate maintenance and inspection work on the primary distribution system.

Starting at the a.c. power station all departments west are supplied with power from two trunk line feeders, the load is tapped from these trunk line feeders at convenient points, by means of hand operated disconnecting switches so arranged that the load can be supplied from either one of these two feeders. Each feeder is capable of handling the entire load by working the copper at a rather high density. However, owing to the short distances the voltage drop is not excessive; in normal operation, however, the load is divided between the two circuits. In general the more important load is connected to one feeder, and the less important to the other. This is done so that the power house operator, in case of trouble on the Pennsylvania Power & Light Company's system, can relieve the load on the power station quickly, by opening the feeder carrying the less important load.

In general, transmission towers are mounted on top of buildings wherever possible, in order to save ground space through the congested portions of the plant.

Going east from the a.c. power station, the two tie lines mentioned above are carried on the same type of towers as the trunk lines going west. Some load is tapped from these two tie lines. The tie lines terminate at separate switches, in both the a.c. power station and the Minsi Trail sub-station. Minsi Trail sub-station is in reality a central switching station in which the purchased power and the generated power is connected together on busses through convenient switches, and in turn is distributed through what is known as the loop system over all of that portion of the plant east of the Minsi Trail sub-station, which includes Sau-

con Division, as well as a portion of the Lehigh Division.

There are duplicate busses in the Minsi Trail sub-station each of which is divided in the middle so that it is possible to obtain almost any combination of incoming and outgoing lines. Normal operation at present is to use but one buss. However, under certain circumstances two busses will be used and by means of proper relays it is entirely possible to segregate any particular vital load, such as the pumping station on a section of this buss which is fed by one of the tie lines from the a.c. station which in turn is connected to a bus in the a.c. power station which is fed by one or more engines. The operation of a single relay could then directly connect the pumping station to these engines and isolate this particular portion of the load from the balance of the plant. Up to date it has not been found advisable to operate in this manner, but the physical layout of the switches and feeder lines make this easily possible.

The loop system is protected by means of balanced relays. The principle of this system was described in a paper by D. M. Petty on the subject, "Transmission and Distribution of Power in Industrial Plants," published in the 1920 proceedings of the Association Iron and Steel Electrical Engineers. It is sufficient to say that this system has now been in operation long enough for us to have every confidence in it.

Low tension distribution is all made at 220 volts, the d.c. sub-station operating with a bus voltage of from 230 to 240 volts; the a.c. transformers likewise having a secondary terminal voltage of about 230. It was felt that it would be better to adopt this low voltage as a standard on account of its ease of installation and because it was recognized that 440 or 550 volts is almost as dangerous as 2200 or 6600 volts. The records

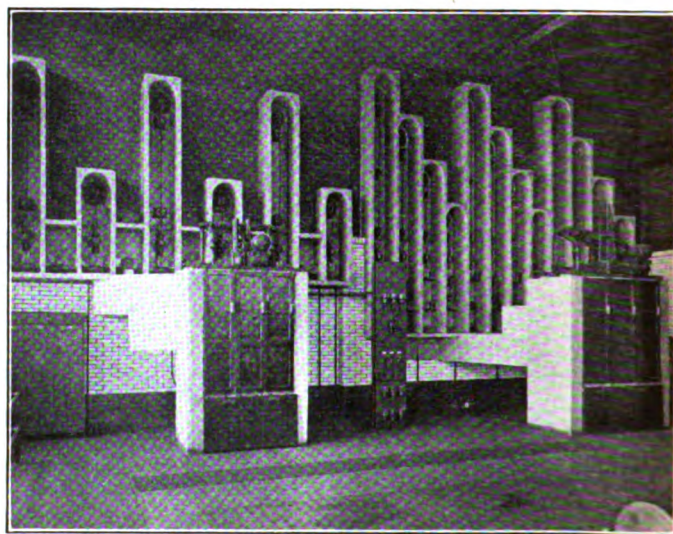


FIG. 5—Interior car dumper sub-station. Showing loop system coming in on right, going out on left. Relay panel in center. Busses under floor.

in a great many plants show that more men are seriously injured or killed on the 440 or 550 volt systems than on high voltages due to the fact that the men in the operation of the majority of the plants have greater opportunity for coming in contact with this voltage than with the primary voltage. However, the record of fatalities on 220 volts either a.c. or d.c. are almost negligible; at least it can be said that 220

volts is practically no more dangerous than 110 volts, whereas 440 volts steps into the class of killing voltages. It should be noted that wherever possible and where the conditions warrant it, the various 220 volt d.c. distribution systems are connected together, as pointed out under the heading of "Operation of Power Systems." This is also true of the low tension a.c. system. In neither case, however, is any attempt made to operate either the sub-stations or the transformer banks in parallel, although with proper adjustments this could be done.

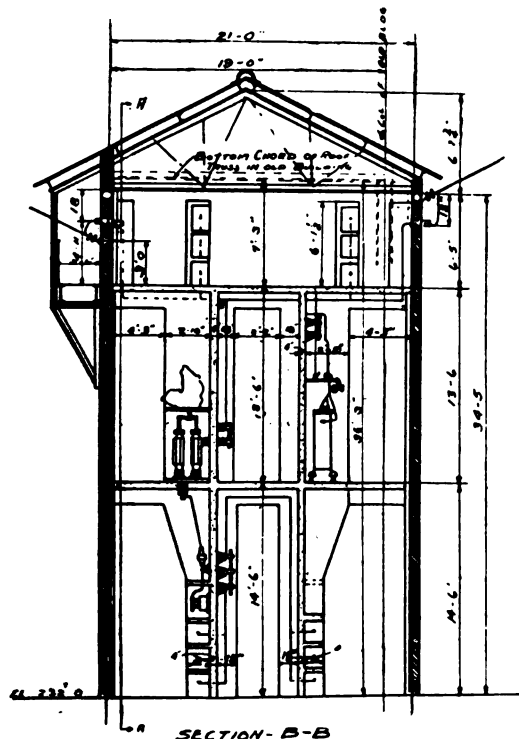


FIG. 6—Cross section of Minsi Trail sub-station, showing duplicate busses on first floor with selective disconnecting switches. Oil switches and lightning arresters on the second floor and outgoing feeders on the third floor.

MANUFACTURING DEPARTMENTS

(Which comprise the July description are enumerated below)

Lehigh Division.

Blast Furnaces
 No. 1 Open-Hearth
 Steel Foundry
 Forge Departments
 Drop Forge Department
 No. 2 Machine Shop
 Central Tool Dept.
 Tool Steel Dept.
 Wheel Department
 No. 6 Machine Shop
 Iron Foundry
 No. 3 Open-Hearth
 No. 2 Merchant Mills
 18-in. Continuous Billet Mill
 22-in. Bar Mill
 12-in. Bar Mill
 10-in. Bar Mill
 8-in. Bar Mill

No. 3 Merchant Mills
 12-in. Crucible Bar Mill
 9-in. Crucible Bar Mill
 Brass Foundry
 Treatment Departments
 No. 8 Machine Shop

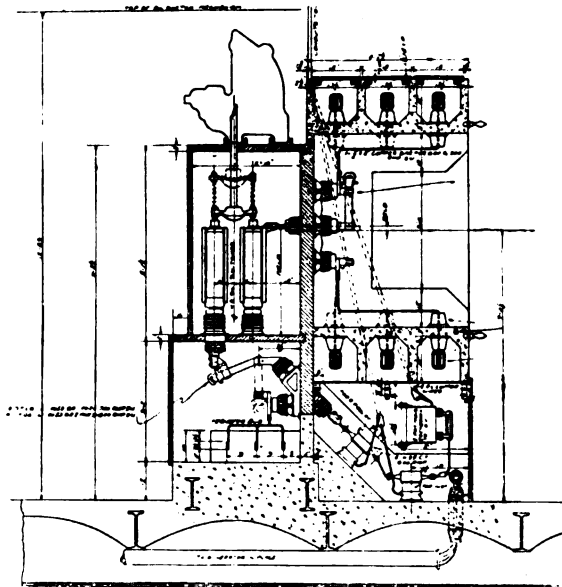


FIG. 7—A.C. power station. Showing cross section of oil switch with duplicate buss structure at rear of switch and transfer buss in bottom of cell.

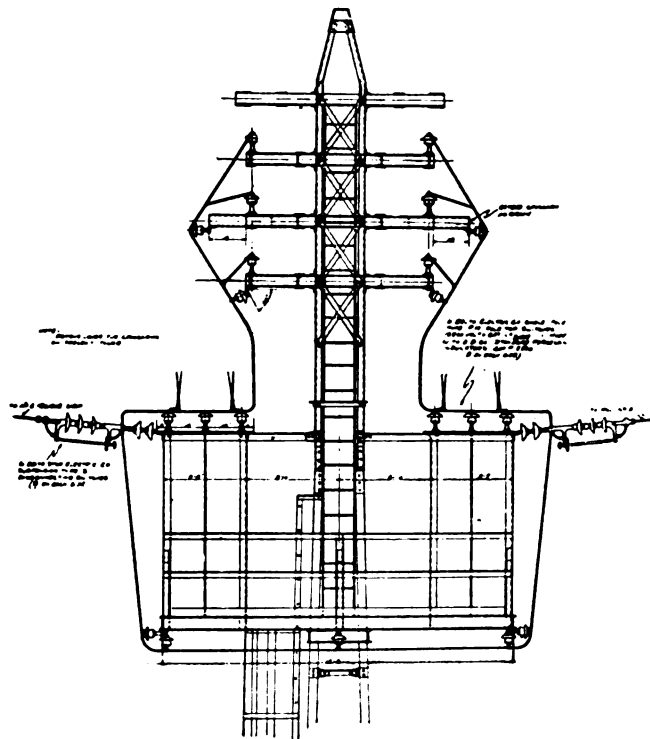


FIG. 8—Showing tower top carrying two buss feeders and means for tapping off two branch circuits through outdoor type disconnecting switches, operated either from platform or ground.

No. 2 Projectile Dept.
 Ingot Mould Foundry
 Cinder Dump
 Redington Proving Ground
 Electrical and Mechanical Repair Shops

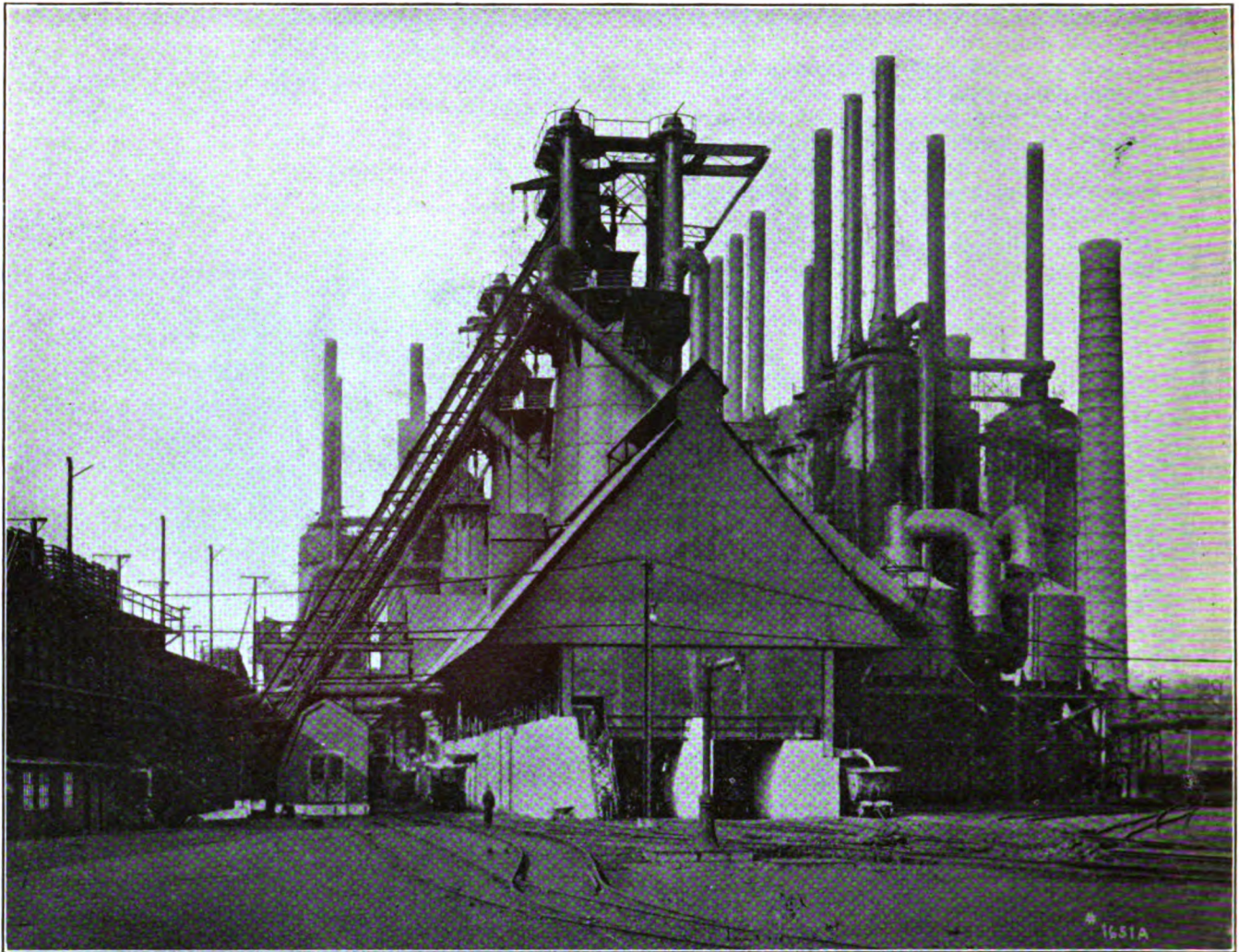


FIG. 9—Blast furnaces. Ore bins left, dust catcher and wet washer right.

Saucon Division.

Open-Hearth Dept.

Soaking Pits

Mills

42-in. Bethlehem Shape Mill

48-in. Bethlehem Shape Mill

46-in. Blooming Mill

48-in. Finishing Mill

40-in. Blooming Mill

28-in. Structural Mill

30-in. Billet Mill

28-in. Rail Mill

18-in. Structural Mill

12-in. Structural Mill

Structural Shipping Yards.

Fabricating Shops

Pumping Station

Lubricants Used in Boiler Rooms

"Combustion" for May has a valuable contribution by Allen F. Brewer under title "Selecting and Handling Lubricants for the Boiler Room."

Selection of boiler room lubricants is most important. Steam cylinders, external oiling of pump rocker arms, etc., motor bearings, chain drives should be amply cared for by three grades of selected lubricants.

Cylinder oils are available for various specific temperature ranges. The percentage of animal oil compounded to insure the "sticking quality," should be carefully watched, a pure mineral oil will not adhere to wet surfaces. Where high super-heats are developed, animal oils are unnecessary, and should be avoided, especially where open-heaters recover the exhaust.

External lubrication is a matter of local determination. Intricate types of stoker drives and motors often

require a good grade of red engine oil having a viscosity of 300-500 sec. Saybolt at 100 deg. F. Sight feed oil cups, etc., should be flushed and cleaned frequently. Chain and gear compounded should have a viscosity of 1000 sec. Saybolt at 210 deg. F.

In handling and storing lubricants, waste and contamination should be guarded against. Wooden barrels should not be used for storing, steel barrels overcoming most of the difficulties arising from loss in transfer, dripping, and evaporation, at the same time decrease the fire hazard.

A central cylinder lubrication will usually show marked operating results and decreased oil expense.

Lubrication efficiency should be grouped with fuel efficiency, in order to postpone the day when the abnormal consumption of petroleum resources throughout the world have forced the adoption of substitutes.

American Iron and Steel Institute Annual Meeting

1500 Members at Hotel Commodore Listen to Chairman Gary's
Notable Address—Charles M. Schwab Concludes Reading
When Judge Gary Is Unable to Continue

THE preliminary report of a special committee authorized to investigate the advisability of adoption of the 8-hour day, was the main theme of Judge Gary's address. The tenor of the report was adverse toward the short-day in practice at present.

In giving the preliminary report of the special committee Mr. Gary made it plain that it was not conclusive or final. Under present conditions, he said, shortening the work day would create an acute situation in the industry because of labor shortage and the huge demand for iron and steel. At least 15 per cent would be added to the cost, he said, and 60,000 more employees to the industry.

The report on the 12-hour day was the first public statement of the committee named by Mr. Gary with himself as chairman after a dinner with President Harding at the White House where the subject was the chief topic of discussion.

In the following words the chairman analyzed the committee's investigation:

"Apparently the underlying reason for the agitation which resulted in the appointment of this committee was based on a sentiment, not created or indorsed by the workmen themselves, that the 12-hour day was an unreasonable hardship upon the employees who were connected with it; that it was physically injurious to a large percentage of the employees, and that it interfered with family associations essential to the welfare of the children; that for these reasons it was, in a sense, opposed to the public interest," the report began.

Say Men Prefer Long Shift.

"Whatever will be said against the 12-hour day in the steel industry, investigation has convinced this committee that the same has not of itself been an injury to the employees, physically, mentally, or morally. Whether or not in the large majority of cases 12-hour-day men devote less time to their families than the employees working less hours is perhaps questionable."

Because the steel industry is largely a continuous process, there must be three eight-hour shifts or two 12-hour shifts, the committee believes. The workmen, as a rule prefer the longer shift because it means more pay they find. And "there is less physical work, as a total per day, and less fatigue from the work of a 12-hour day in the steel industry than pertains to the large majority of eight-hour men."

Not Detrimental, He Says.

In an address before the institute Judge Gary, who has just returned from a Mediterranean cruise, asked for a greater turning toward the Christian religion as a cure for the world's ills in his address opening the institute.

Disclaiming any intention to "preach a sermon,"

Mr. Gary declared religion was "simple, plain business sense."

"Gentlemen," he said impressively, "it is in accordance with our instincts and judgment, as frequently proclaimed, to say that it pays a nation or an individual to follow a Christian course."

Bible as Code of Conduct.

"The moral and religious principles of the Bible, both the Old and New Testaments," he declared, "have never been and never can be successfully combated. Since the preservation of history commenced there has never been anything approaching the Holy Bible as a literary production or a code for proper and desirable human conduct, or as a foundation for future hopes."

Analysis of Conditions.

Mr. Gary reserved his customary analysis of conditions in the steel industry for the end of his address, when he asserted, optimistically, that "there is nothing in sight to indicate that there will be a substantial diminution of the demand for finished steel in this country during the next six months, to say the least." He warned steel manufacturers, however, not to permit prices to go above the level which is "fair and reasonable."

Touching on the Ruhr situation, which he declared was unsettling all Europe, he suggested that Secretary of State Hughes be named as an impartial arbitrator to settle the international differences between France and Belgium and Germany.

Of conditions in the United States Mr. Gary said:

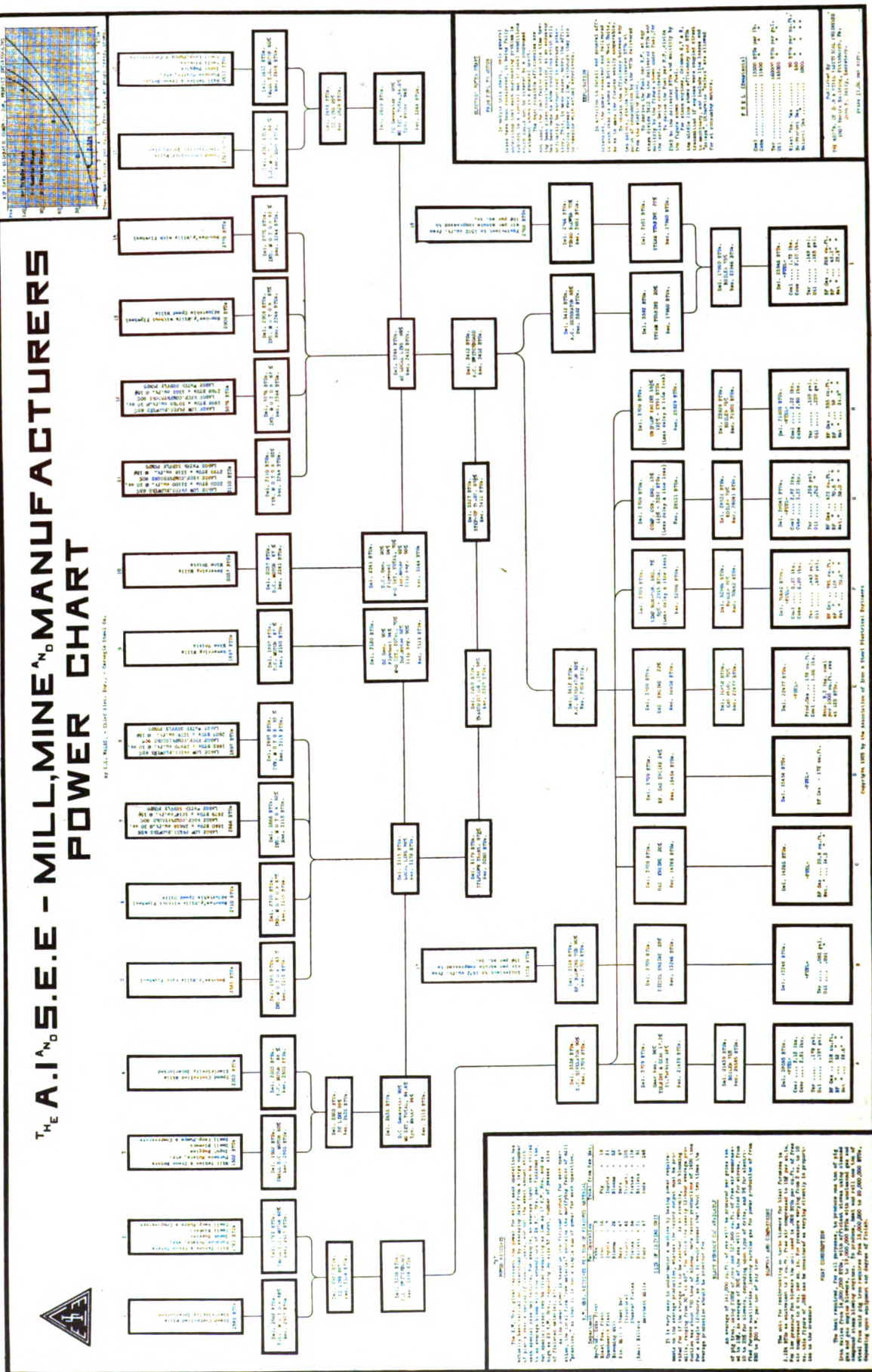
"When one considers the wealth, resources, increasing production, and purchasing necessities of this country," he said, "the present business outlook is good. All this is said in the face of very heavy burdens of taxation, unnecessary and unreasonable political and social agitations precipitated by those who have nothing financial at stake, the unfortunate troubles pending in foreign countries, and the bugbear of politics."

Sees No Business Slump.

"There has of late apparently been a deliberate and persistent attempt to create an impression that there will be in the near future, a substantial recession in business activities," he asserted. "Business men generally understand this. The propaganda is inspired by a few short-sighted persons who do not seem to understand that if they could succeed in wrecking the business structure they would themselves be buried in the ruins."

Scores High Prices.

"Of course, as always, conditions may change materially and suddenly, depending upon circumstances, but the necessities of consumers in the United States and of those in foreign countries who are our customers are so great, the population is increasing so rapidly, and



The Chart is being distributed, and can be secured upon application to John F. Kelly, Secretary, The Association of Iron and Steel Electrical Engineers, Empire Bldg., Pittsburgh, Pa.

the ability to buy and pay for steel, as shown by the financial statements, so large, there is within view no reason to suppose there will be, certainly not in the near future, a material slackening in demand and use."

"Building operations, though important, are a small percentage of our business."

The guest of honor was Prince Gelasio Caetani, the Italian Ambassador to the United States. The Prince lauded the Fascisti and compared their ideals to those of the Bolsheviks. He appealed to Americans for a more complete understanding of modern Italy, her world aims and purposes.

Mr. W. U. Follansbee contributed humorously in a bright and cheerful essay.

Other important contributions by well-known members included the following papers:

"The Disintegration of Fire-Brick Linings in Iron Blast Furnaces," by C. E. Nesbitt and M. L. Bell, Research Engineers, Carnegie Steel Company.

"The Standardization of Steel Mill Practice Through Time Study," by Robert Gregg, president, Atlantic Steel Company.

"The Value of Chemistry in the Iron and Steel Industry," by Wm. A. Forbes, Metallurgist, United States Steel Corporation.

"A Motor Driven Rolling Mill," by H. E. Davis, Chief Electrician, Interstate Iron and Steel Company.

(An illustrated article on this mill by Mr. Davis appeared in the February, 1923, issue of this magazine.)

"Waste in the Steel Industry," by H. T. Morris, Metallurgical Engineer, Bethlehem Steel Company.

"Theory of Gas Producer Practice in Steel Works," by Waldemar Dyrssen, Metallurgist of the United States Steel Corporation.

*The Largest Enamelling Furnace in the World**

This Exceptional Size Furnace Removes Many of the Difficulties Previously Encountered in the Production of Large Enamelled Vessels. Heat Distribution Uniform Throughout, by Triple Gas Heating With Both Gas and Air Under Pressure Control.

The production of enameled steel tanks for special purposes began with the manufacture of single rings of a height of 750 to 1500 mm. (29 to 58.5 in.), which were bolted together to form a single vessel and caulked with tin. The caulking was always the cause of bringing on fermentation. It was found that the enamel frequently scaled under very slight pressures at the caulks, whereby frequently whole vessels were rendered useless. The idea of manufacturing the whole vessel out of one piece was impractical because of the lack of a suitable furnace. The specifications for a furnace to enamel uniformly vessels up to 6 m. (19.7 ft.) in length and 3 m. (9.8 ft.) in diameter are very stringent. Even in the ordinary enameling furnaces for small and medium pieces the equal distribution of heat not only from front to back, but also from above to below, is not easy to attain.

The furnace described represents a pleasing advance in German technology. The heating cham-

ber is 7x5x5 m. (23x16.4x16.4 ft.) The absolutely uniform distribution of heat in all parts of the heating chamber is obtained by the use of triple gas heating, in which the gas and the air are forced in under pressure.

The substructure of the furnace with the combustion chambers a, b and c is built as a huge heat reservoir. The furnace can be so heated that the gases pass from the draughts d and e straight through the heating chamber towards f. The gases can also be led as indicated through the arches; by means of controls built in for the purpose the gases can be directed to any desired point.

The door is especially carefully constructed as it must close very tightly. The very large forces acting on the door because of its size and the temperature, made a special construction with provision for applying pressure necessary in order to prevent the warping of the door. The door and the loading device are electrically operated. The waste heat is thoroughly utilized in order to increase the economy of the plant. The hearth loss is only 12 per cent of the total heat supplied.

The enameling of a vessel 6 m. long and 3 m. in diameter takes 60 minutes. The fuel consumption for continuous operation is 9,000 kilos of pit coal of 7,000 calories per 24 hours; considering the size of the heating chamber this is a very low figure.

The neatness of the whole plant deserves comment. In other enameling furnaces the chief rubbish arises from the removal of the slags. In spite of the baffles, dust reaches the heating chamber and workroom and contaminates the work. In this place the ashes are removed from a water bath without any annoyance to the workers by heat or dust. An important point in the construction, which is due to Zahn & Company, Construction and Enameling Works, Berlin, is that brown coal in the form of briquets or as raw coal can be used.

Book Review

Metals and Their Alloys.—By Charles Vickers. A practical work dealing with metals from their origin to their useful application, where strength, ductility, toughness, durability, lightness, color, hardness, cheapness, conductivity, or bearing properties are demanded.

A revision of the work of Brannt published under the title of "Metallic Alloys" by an authority. The author is a specialist in melting, alloying and casting metals, a technical adviser to manufacturers of non-ferrous castings; he is non-ferrous editor of Foundry, and metallurgical editor of Brass World.

The first work on alloys containing a comprehensive and authoritative section on the occurrence of metals in ores, and their extraction therefrom. The foundryman can here obtain the necessary fundamental knowledge that he should possess.

Indispensable to everyone interested in the preparation and use of alloys. Describes their physical and chemical properties, and their various applications in the arts and industries.

A complete, practical guide for the metal worker, a convenient reference for the trained technical man, and a source of inspiration for the engineer who must select alloys suitable for his purpose.

800 pages, 110 illustrations, cloth, price \$7.50. Published by H. C. Baird & Company, New York City, N. Y.

*Zeitschrift des Vereines Deutscher Ingenieure.

Coke Quality and Blast Furnace Operations

A Review of the Work of Dr. Heinrich Koppers

By F. W. SPERR, JR.* and D. L. JACOBSON†

PART I

ABOUT seven years ago, H. P. Howland, Superintendent of Blast Furnaces of the Wisconsin Steel Company published a paper entitled "Calculations with Reference to the Use of Carbon in Modern American Blast Furnaces"‡ which aroused world-wide interest, and which would certainly have been immediately followed up with a series of additional investigations by Howland himself and by other authorities, had it not been for the urgent distractions of the war.

Howland made a thorough investigation and comparison of actual operating results obtained at 26 different American blast furnaces. These furnaces were all using Mesaba ores and their operation could be taken as fairly representative of American practice with such ores. The consumption of coke per ton of pig iron was found to vary from 2615 lb. to as low as 1584 lb. There was no great difference in the carbon content of the cokes used; the percentage gasified at the tuyeres and the wind required per pound of coke were practically the same in each case, and so the important practical conclusion was reached that the great difference in coke consumption must be attributed mainly to differences in the rate of combustion of the coke at the tuyeres. In Howland's own words, "The most desirable thing about a coke is that quality in the carbon which will allow of its being instantaneously burned to CO and thus result in the maximum concentration of heat where needed."

It is safe to say that the majority of American blast furnace authorities are in agreement with Howland. Hermann A. Brassert in his well-known paper, "Modern American Blast Furnace Practice"§ clearly stressed the importance of coke combustibility, and in a subsequent article^o he enlarged on the subject, pointing out the disadvantages of slow burning coke and stating, "For blast furnace use, therefore, a coke must be produced which will burn rapidly at the tuyeres and yet not be too vulnerable to the gases." It is interesting to note that this opinion that a fast burning coke is necessary to obtain the best results in blast furnace operation, is exactly the reverse of the view that generally prevailed fifteen years ago, and which still prevails to a large extent in Europe. The revolution in American opinion and practice has been due to the introduction and rapid adoption of the modern by-product coke oven, to the means of controlling coke quality which were formerly lacking and which this has supplied, and to co-operation between the operators of the by-product coke ovens and blast furnaces. After the first few modern by-product-coke plants were installed,

10 to 12 years ago, it was speedily recognized that the old prejudice against by-product coke would have to give way, that furnaces operating with properly made by-product coke were giving—not merely "just as good" results—but better results than they formerly gave with beehive coke. With this recognition, all open-minded blast furnace men were willing to go further and entirely revise their views of coke quality

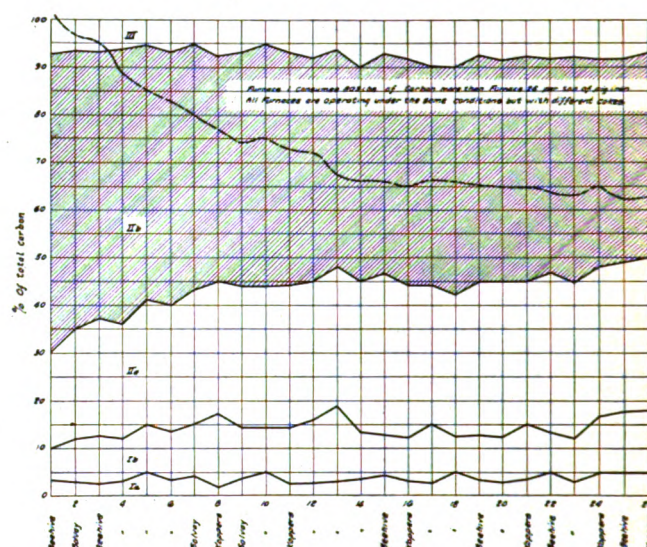


FIG. 1—Percentage distribution of carbon in furnace operations.

in general. To this departure from tradition and readiness to set up new standards of quality and performance made possible by the introduction of improved methods, has been due the present acknowledged superiority of American over European blast-furnace practice.

Although much has been accomplished in the way of improving blast furnace operation, increasing output and reducing coke consumption, it would be a serious mistake to say that the limit of possibilities had in any way been approached. It should be well recognized that we have made but a bare beginning in our knowledge of the relation of coke quality to blast furnace operation. Coke is the only artificially manufactured material entering the blast furnace. Aside from simple mechanical preparation, the other materials in the burden must be taken as they come. Coke alone can be varied in quality within wide limits, and in the modern by-product coke oven we have an apparatus more and more capable of adjustment to produce a uniform, definite and well regulated coke. In order to take full advantage of this, we must know more about the behavior of coke in the blast furnace, the properties required to obtain the best results, and methods of measuring and determining these qualities, and our information in all of these respects is sadly lacking.

The recent work of H. Koppers in Germany is of great interest and value in this connection. In a paper

*Chief Chemist the Koppers Company.

†Research Chemist the Koppers Company.

‡Bulletin American Institute Mining Engineers, March, 1916; Transactions American Institute Mining Engineers (1917), v. 56, p. 339.

§Yearbook American Iron and Steel Institute, 1914, p. 15.

^o"Notes on Blast Furnace Coke with Particular Reference to Combustibility," see "The Principles, Operation and Products of the Blast Furnace," by J. E. Johnson, Jr., 1918, p. 171.

TABLE I*

Furnace No.	Month Year	Kind of Coko		Gas Analysis—Per Cent by Volume										Calculated Quantities per Ton Iron			Pounds Carbon per Ton Iron		Per Cent Carbon Burned at Tuyeres			
		Method of Manufacture	Operation	CO ₂	CO	CH ₄	CO ₂	CH ₄	N	H	Lbs. Carbon to Gas	Cu. Ft. Gas 62° F.	Cu. Ft. Air 62° F.	Cu. Lb. Air	Total Charged	Gasified in Furnace	Gasified in Tuyeres	Per Cent Total Carbon	Per Cent Gasified Carbon			
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	12/11	2,615	301	86.3	BH	Stonega	10.3	27.6	0.2	38.1	59.8	2.1	2,251	187,200	141,600	54.2	2,254	2,110	1,868	82.8	88.6	
2	1/12	2,551	272	84.4	BP	Solvay	11.3	26.9	0.6	38.8	59.0	2.2	2,182	178,200	132,800	52.0	2,153	2,049	1,751	81.4	85.6	
3	1/13	2,472	482	86.1	BH	Conn.	12.3	25.8	0.0	38.1	58.4	3.5	2,133	177,300	131,000	53.0	2,128	1,996	1,728	81.2	86.6	
4	12/14	2,247	450	87.1	BH	Conn.	11.8	26.2	0.1	38.1	58.5	3.4	1,978	164,440	121,600	54.2	1,957	1,846	1,605	82.0	87.0	
5	8/14	2,198	499	86.9	BH	Conn.	12.5	26.8	0.3	39.6	58.0	2.4	1,933	154,600	113,200	51.6	1,908	1,813	1,494	78.7	82.4	
6	4/14	2,123	541	88.3	BH	Conn.	12.8	26.0	0.2	39.0	58.0	3.0	1,905	154,800	113,500	53.4	1,875	1,764	1,498	79.8	84.9	
7	11/13	2,115	360	84.3	BP	Solvay	14.2	25.3	0.0	39.5	57.9	2.6	1,826	146,500	108,200	51.2	1,782	1,683	1,427	80.1	84.8	
8	12/14	1,996	490	86.3	BP	Koppers	13.8	26.0	0.2	40.0	57.4	2.6	1,718	136,100	98,800	49.5	1,722	1,616	1,303	75.6	80.6	
9	6/15	1,936	376	85.7	BP	Solvay	14.6	24.7	..	39.3	57.4	3.3	1,689	137,000	98,900	51.1	1,659	1,557	1,305	78.8	83.7	
10	9/15	1,905	393	88.7	BP	Solvay	14.5	26.0	..	40.5	56.4	3.1	1,700	132,900	94,900	49.8	1,690	1,575	1,252	74.1	79.5	
11	2/15	1,901	517	85.5	BP	Koppers	13.6	24.9	0.2	38.5	58.0	3.2	1,600	131,700	96,600	51.8	1,625	1,514	1,274	78.4	84.1	
12	11/14	1,863	504	86.6	BP	Koppers	14.0	25.3	0.2	39.5	57.4	2.6	1,602	128,500	90,500	50.0	1,614	1,513	1,230	76.2	81.3	
13	5/14	1,780	426	84.9	BP	Koppers	14.2	26.0	..	40.2	56.2	3.6	1,519	120,000	85,200	48.0	1,511	1,414	1,124	74.4	79.5	
14	10/15	1,742	503	84.6	BP	Koppers	15.4	22.8	1.2	39.4	57.1	3.7	1,480	119,000	85,925	49.3	1,474	1,382	1,133	76.9	82.0	
15	10/14	1,716	542	87.1	BH	Benham	15.7	22.8	..	38.5	57.8	3.7	1,505	123,800	93,200	54.2	1,494	1,396	1,194	80.0	87.0	
16	10/15	1,715	585	84.6	BP	Koppers	15.4	22.6	1.4	39.4	57.1	3.5	1,456	117,300	84,530	49.3	1,451	1,357	1,114	76.7	82.2	
17	4/14	1,702	543	87.5	BP	Koppers	14.2	25.2	0.2	39.6	57.3	3.1	1,476	127,500	85,600	50.3	1,490	1,388	1,130	75.9	81.5	
18	6/14	1,699	572	87.0	BP	Koppers	14.9	23.5	0.2	38.6	57.3	4.1	1,472	120,800	87,600	51.6	1,479	1,376	1,155	78.2	83.9	
19	2/15	1,673	580	88.6	BH	Benham	15.1	23.6	..	38.7	58.6	2.8	1,477	121,000	89,600	53.4	1,482	1,384	1,182	79.9	85.0	
20	1/15	1,658	590	88.3	BH	Benham	15.5	22.9	0.1	38.5	58.7	2.8	1,467	120,600	89,600	54.0	1,464	1,366	1,182	80.8	86.5	
21	5/15	1,636	442	89.5	BP	Koppers	14.2	25.2	0.2	39.6	57.6	2.8	1,464	117,100	85,200	52.0	1,463	1,369	1,124	76.8	82.1	
22	5/15	1,635	593	88.5	BH	Benham	15.5	23.3	0.0	38.8	58.3	2.9	1,434	117,000	85,200	52.1	1,447	1,349	1,124	77.7	83.4	
23	3/15	1,624	592	87.3	BH	Benham	14.8	23.6	0.2	38.6	58.3	3.1	1,401	115,000	84,800	52.2	1,417	1,317	1,118	79.0	85.0	
24	6/15	1,623	457	89.6	BP	Koppers	15.3	24.8	0.2	40.3	57.0	2.7	1,453	114,700	82,600	50.9	1,454	1,360	1,090	75.0	80.2	
25	4/15	1,589	608	88.3	BH	Benham	15.3	23.5	0.0	38.8	58.2	3.0	1,390	103,400	83,300	52.4	1,403	1,307	1,100	78.5	84.2	
26	7/15	1,584	466	89.2	BP	Koppers	15.7	24.6	0.2	40.5	56.9	2.6	1,423	111,300	80,100	50.6	1,413	1,324	1,057	74.8	79.9	

*Transactions American Institute Mining Engineers (1917) vol. 56, p. 342.

TABLE II*—DATA ADDITIONAL TO THAT OF TABLE I

Furnace No.	Dimensions			Diameter	Per Cent Carbon							Pounds per Ton Iron			Engine Room Report						
	Heights	Hearth	Bosh		Stock Line	Capacity Cu. Ft. Taperes to Stock Line	No. Taperes	Date Last Blown In	Per Cent Silicon In Iron	Iron	Stone	Flue Dust	Coke Dried	Screenings	Per Cent Moisture In Coke	Stone Used	Flue Dust Made	Cu. Ft. Air Per Min.	Temp. Air to Tubs	Grains Moisture	Per Cent Coke Screened Out
1	84'	13' 4 1/2"	13'	19' 3"	14'	14,060	8	9-09	1.62	4.0	11.8	25.0	88.7	80.0	2.25	1,192	225	30,040	34°	1.83	0.5
2	80'	11'	11'	16'	12'	9,200	8	9-09	1.59	4.0	11.6	5.4	88.5	80.0	4.0	1,148	275	25,295	...	1.55	0.75
3	89'	13' 10"	15' 6"	20' 6"	16'	18,500	12	9-10	2.13	4.0	12.0	11.7	88.1	...	2.25	1,144	370	45,560	62°	...	...
4	85'	13'	16'	22'	16'	19,500	12	...	1.56	4.0	12.0	8.2	89.8	82.0	2.5	1,097	461	44,213	82°	...	0.56
5	85'	13'	16'	22'	16'	19,500	12	...	1.40	4.0	12.0	8.2	89.4	82.0	2.5	1,003	388	45,839	92°	6.44	0.39
6	89'	13' 10"	15' 6"	20' 6"	16'	18,500	12	9-10	1.93	4.0	11.7	12.0	90.7	80.0	2.25	1,208	180	46,090	52°	3.15	0.5
7	80'	12' 11"	12'	18' 6"	13' 6"	12,375	8	9-12	1.53	4.0	12.05	11.6	89.1	81.5	4.00	1,190	116	32,390	70°	4.28	1.5
8	94'	11' 7"	17'	21' 3"	16' 3"	20,666	12	2-14	1.03	4.2	11.75	9.0	88.5	...	2.50	870	140	39,210	38°	1.05	...
9	80'	11' 11"	13' 6"	18' 6"	14'	12,459	8	5-15	0.94	4.1	12.05	4.8	89.4	84.0	3.85	1,101	224	30,799	90°	5.9	0.3
10	80'	11' 11"	13' 6"	18' 6"	14'	12,459	8	5-15	1.25	4.4	12.0	8.5	91.6	84.0	2.9	1,042	192	31,120	85°	6.6	0.3
11	Same as	No. 8	No. 8	...	...	...	...	...	0.90	4.25	11.93	11.45	88.3	...	3.07	719	140	36,824	37°	2.58	...
12	Same as	No. 8	No. 8	...	...	...	...	...	0.95	4.20	11.75	7.55	88.85	...	2.50	755	98	38,220	54°	2.04	...
13	78'	19' 10"	14'	19' 6"	15'	15,584	9	3-14	1.26	4.00	11.70	...	88.00	...	3.50	897	60	29,670	62°	...	...
14	85'	14' 3"	15'	20' 6"	15' 5"	...	12	1-15	1.00	4.00	12.00	2.00	89.1	87.0	4.32	828	135	36,368	60°	4.0	1.7
15	90'	14'	16' 6"	21' 6"	16'	20,222	12	9-14	1.62	4.00	12.00	10.0	92.0	80.0	1.55	912	89	35,385	65°	...	3.2
16	90'	14' 3"	16' 6"	21' 4"	16' 6"	...	12	9-13	0.89	4.00	12.00	2.1	89.1	87.0	4.32	833	200	42,765	60°	3.9	1.6
17	90'	14' 6"	17' 8"	22'	17'	20,630	10	2-14	1.23	4.20	11.75	6.2	89.5	...	2.25	752	95	42,950	49°	2.5	...
18	Same as	No. 17	...	...	...	...	...	...	1.35	4.20	11.75	8.25	89.0	...	2.30	804	82	48,970	75°	5.5	...
19	Same as	No. 15	...	...	...	...	...	...	1.56	4.00	12.00	9.5	93.3	80.0	1.85	780	94	35,615	62°	2.2	3.8
20	Same as	No. 15	...	...	...	...	...	...	1.41	4.00	11.9	9.1	92.5	80.0	2.23	849	90	35,820	62°	1.7	2.8
21	Same as	No. 13	...	...	...	...	...	...	1.36	4.1	12.0	4.8	91.8	...	2.5	792	31	30,050	70°	3.8	...
22	Same as	No. 15	...	...	...	...	...	...	1.62	4.0	11.9	8.0	92.2	80.0	1.4	709	99	35,210	56°	3.8	3.0
23	Same as	No. 15	...	...	...	...	...	...	1.48	4.0	11.7	8.8	91.2	80.0	1.6	714	125	35,680	62°	1.8	3.0
24	Same as	No. 13	...	...	...	...	...	...	1.19	4.1	12.0	6.9	91.9	...	2.5	775	...	29,910	75°	5.0	...
25	Same as	No. 15	...	...	...	...	...	...	1.67	4.0	11.7	7.1	92.3	80.0	1.5	712	94	35,570	62°	3.4	3.3
26	Same as	No. 13	...	...	...	...	...	...	1.20	4.1	12.0	7.6	91.5	...	2.5	828	...	30,210	80°	6.4	...

*Transactions American Institute Mining Engineers (1917) vol. 56, p. 343.
Furnaces No. 24 and No. 26 used more flue dust than produced.

TABLE III—COMPUTATIONS FROM HOWLAND'S DATA WITH DATA FROM OTHER SOURCES

Furnace No.	Lb. Carbon Gasified in the Furnace per Ton Iron	Ratio		% of Total Oxygen Reduced			% Total Carbon Gasified				Remain- ing for the De- rection of Iron Ore. %	Atoms Oxy- gen Reduced per 100 Atoms Carbon	Time of Transit in Hours	Tons per sq. ft. Hearth per 24 Hours
		CO ₂	CO	Total %	Directly After De- ducting Sil. P, etc. %	Indirectly %	Gasified Before the Layers %	Performing Double Re- duction (Di- rect and In- direct) %	Performing Solely Indi- rect Reduc- tion. %	Performing No Reduc- tion. %	Consumed for Direct Re- duction of Si. P. and H ₂ O In Air. %			
1	2108	0.37	0.37	31.9	25.6	68.1	88.6	10.4	11.6	78.0	2.6	32.4	9.5	2.286
2	2045	0.42	0.42	33.4	27.5	66.6	85.6	12.3	12.2	75.4	3.0	36.8	6	2.880
3	1993	0.48	0.48	32.2	27.2	67.8	86.6	12.8	14.1	73.1	2.8	39.7	8	2.552
4	1843	0.45	0.45	32.4	26.3	67.6	87.0	12.4	13.5	74.1	3.1	38.3	9	2.305
5	1805	0.47	0.47	32.5	29.2	60.5	82.6	16.2	10.8	73.0	5.1	43.2	8.5	2.524
6	1763	0.475	0.475	34.0	26.9	66.0	84.9	14.1	13.3	72.6	3.9	41.5	7.5	2.872
7	1682	0.56	0.56	33.6	27.0	66.4	84.8	15.45	15.0	69.6	4.2	45.9	7.5	3.274
8	1608	0.53	0.53	37.8	35.4	62.4	80.6	18.3	12.0	69.7	1.8	48.6	10	2.222
9	1554	0.59	0.59	33.0	25.8	67.0	83.7	15.7	16.1	68.2	4.5	47.5	8	2.634
10	1575	0.60	0.60	40.5	34.2	59.5	79.5	22.0	10.4	67.6	5.1	54.4	7.5	2.744
11	1523	0.55	0.55	32.7	29.2	67.3	84.1	15.5	16.1	68.4	2.3	47.1	9.5	2.277
12	1512	0.55	0.55	35.8	32.9	64.2	81.3	17.7	13.9	68.4	2.2	49.3	10	2.222
13	1414	0.54	0.54	40.0	35.9	60.0	79.5	20.3	10.3	69.4	3.2	50.9	9	2.771
14	1382	0.675	0.675	28.8	23.1	72.0	85.5	14.0	22.1	65.3	3.7	48.8	ca. 9.5	2.844
15	1395	0.69	0.69	28.0	23.9	72.0	85.5	14.0	22.1	65.3	3.7	51.2	ca. 9.5	2.552
16	1355	0.68	0.68	27.8	22.1	72.9	82.2	13.3	21.2	65.2	3.5	47.8	ca. 9.5	2.725
17	1387	0.565	0.565	34.5	31.2	65.6	81.5	17.0	14.1	68.9	2.9	48.1	10	2.213
18	1387	0.635	0.635	28.2	19.4	71.8	83.4	12.8	19.1	67.5	5.0	45.3	9.5	2.332
19	1382	0.64	0.64	28.6	22.8	71.4	85.0	14.0	20.9	65.1	3.7	48.9	9	2.707
20	1364	0.68	0.68	26.3	20.6	73.7	86.6	12.8	23.1	64.1	3.4	48.7	9	2.781
21	1369	0.565	0.565	35.6	29.3	64.4	82.1	17.0	14.5	68.5	4.0	48.5	9-9.5	2.872
22	1348	0.665	0.665	29.6	23.3	70.4	83.4	15.3	21.0	63.7	3.2	52.0	9.5	2.798
23	1314	0.63	0.63	29.0	23.3	71.0	85.0	14.0	20.4	65.5	3.2	48.4	9	2.798
24	1359	0.625	0.625	36.2	30.5	63.8	80.2	19.2	14.6	66.2	4.4	53.0	9	2.972
25	1306	0.60	0.60	36.4	30.5	63.6	83.0	19.0	14.3	66.7	4.4	52.3	9	2.872
26	1323	0.64	0.64	36.0	29.0	64.0	79.9	19.2	14.9	66.0	5.3	53.3	9	3.018
Charcoal blast fur- nace according to Richards														
Same — Ledebur.														
Coke furnace Gillhausen														
Ormesby-Ledebur.														
1. Spiegel														
2. Steel														
3. Hematite														
4. Thomas Iron.														

*Purely direct reduction.

read before the German Iron Association, May 28, 1921, Koppers took Howland's data as a basis, added some other data from certain German blast furnaces, and presented a very exhaustive study of blast furnace operation with especial relation to coke consumption. This paper, with Koppers' proposals for improving German blast furnace practice, aroused an animated discussion in which many prominent European metallurgists took part and which was continued in the pages of *Stahl und Eisen* during much of the past year. An important part of Koppers' own contributions to the discussion has consisted in educating some of the German technologists to the development in American blast furnace practice; but the entire series of articles contain so much material of general interest, that it has been thought that a detailed review of his would be of value to American readers.

An important and valuable feature of Koppers' paper consists in the many tabular and graphical presentations of blast furnace data. For the purpose of

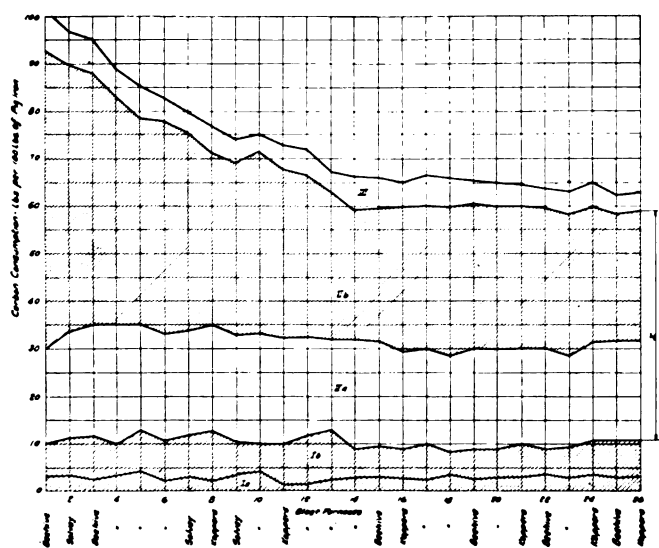


FIG. 2—Curves showing the weight of Carbon per 100 lbs. of pig iron.

this review, the figures in the original articles have been converted from the metric units to the system generally employed in American metallurgical literature, and the diagrams have been entirely redrawn.

Study of Howland's Data.

The original data of Howland are reproduced in Tables I and II. In Table III, Koppers has taken Howland's figures together with data from other sources comprising two charcoal blast furnaces and five German coke furnaces, and made certain additional computations. Table IV gives a compilation of blast furnace data which has been published by O. Simmersbach*. Table V gives additional figures from Gillhausen†, Ledebur‡, and Richards§ in comparison with Howland's furnace No. 19. These tables afford a rich fund of information which deserves careful study.

To facilitate such a study, Koppers has made a graphical interpretation in Figs. 1, 2, 3, of the data for

**Stahl und Eisen*, May 14, 1914, p. 827.

†*Untersuchungen über die Stoff und Warmebilanz des Hochofens. Mitteilungen aus dem eisenhüttenmanischen Institut der Technischen Hochschule Aschen* 1910.

‡*Handbuch der Eisenhüttenkunde*, 3d Edition, Part 2, p. 589-90.

§*Metallurgical Calculations*.

the 26 American blast furnaces investigated by Howland. Fig. 1 shows the percentage distribution of carbon in the various operating events in each furnace. The points on the broken line refer to the numbers on the ordinate and show total pounds of carbon consumed in each furnace per 100 pounds of pig iron. Fig. 2 shows the weight of carbon used in the different op-

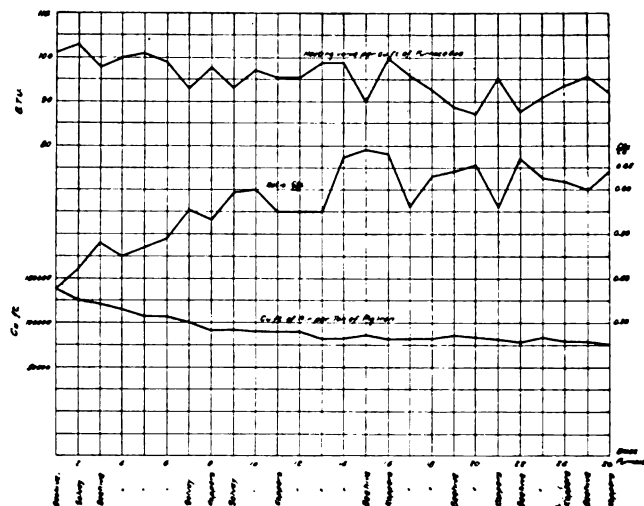


FIG. 3—Quality of blast furnace gas and amount of air per ton of pig iron.

erations per 100 pounds of pig iron. Note that the upper curve corresponds with the broken line on Fig. 1. Fig. 3 shows the quality of the blast furnace gas and the amount of air used in each furnace per ton of pig iron. Fig. 4 is another graphical summary of some of Howland's data published by Koppers in a later article.

As a result of these studies, Koppers comes to full agreement with Howland that the reason for the great differences in coke consumption in the different furnaces must be due to differences in the combustibility of the coke and that other things being equal, the better results are obtained with fast burning coke.

(To be Continued)

C. I. T.'s New Gymnasium Ready in October

According to an announcement, the new \$400,000 gymnasium at Carnegie Institute of Technology, Pittsburgh, now under construction, will be ready for use by October of the present year. Concerted efforts to complete the building by that time are being made by the S. M. Siesel Company of Pittsburgh and Milwaukee, a contracting firm that is headed by S. M. Siesel, a Carnegie Tech graduate of 1908.

The plans, which were designed by Henry Hornbostel, architect, call for one of the finest gymnasiums in the country. The building will consist of four separate units, the women's gym, the men's gym, an administration building, and a swimming pool. Both gymnasiums and the swimming pool, it is said, will be the largest in Pittsburgh. Each gym and the swimming pool will connect, by corridors, with the administration building, which will be located in the center of the group, and which will tower above its connecting units to the extent of one story.

The building will be constructed of light colored brick, stone, terra cotta, and copper. The new gym will bring the Carnegie Tech group up to seven buildings, exclusive of the temporary library, the track and field house, and the dormitories.

Development of the Large Electric Melting Furnace

A Description of the Development of the Large Electric Melting Furnace—Design and Construction of the Largest Electric Melting Furnace Ever Built

By FRANK HODSON*

IN speaking of "large" electric furnaces, the term must be understood to mean the size as compared to the average existing electric furnace. What was considered a very large open hearth furnace ten years ago might well be classed as small today, and in the same way what is now considered a large electric furnace may be small a few years hence.

One of the reasons hitherto against the development of large electric furnaces has been that the older system of three top electrodes does not, for very good electrical and metallurgical reasons, lend itself to multiples of three electrodes. Thus the size of such a furnace is pretty well limited by the current-carrying capacity of the three largest commercial sized electrodes that can be bought and used in steel furnaces. This limit has just about been reached at 40 tons of hot metal and three 24-in. electrodes.

Mechanically, there is no reason why electric furnaces cannot be built just as large as open hearth furnaces, and if we remove this three-electrode limitation in size, we open up a new field of design and utility for the large electric furnace.

The size of a finishing electric furnace for tool steels is somewhat restricted by the necessity of casting small ingots—as compared to, say, gun or armor ingots—and by the need for accurate control of pouring temperatures. This condition does not, however, apply to furnaces used as an intermediate process, say, between the blast furnace and the finishing furnaces. Provided power can be obtained at a reasonable rate, electric furnaces of very large capacity can be usefully and economically employed as a feeder to smaller finishing furnaces.

The modern metallurgical tendency is toward increased size of melting furnace; this is particularly noticeable in recent open hearth plants and it is now generally recognized that handling large quantities of metal is much more economical than small—refining is quicker, metal is more homogeneous and heat losses are less.

The "Greaves-Etchells" furnace, first introduced in 1915, enables the furnace builder to double up on the number of electrodes he can use without disturbing either the electrical or the metallurgical efficiency of the furnace. Two, four, six or eight electrodes can be used, or any multiples of these numbers, so the size of the furnace is limited only by practical design and requirements. At the same time, the supply station is given a well balanced load and high power factor. Large three-electrode furnaces are subject to much greater fluctuations than the four, six or eight electrode "Greaves-Etchells" furnace, and the latter furnace also meets the metallurgists' objections to entire source of heat being over the charge. When all the heat is over the bath, the top layers of metal must be heated too hot in order to

get the metal lying nearer the furnace bottom to correct temperature. The temperature of the bath will always grade from the hottest part of the furnace under the arcs to the coldest near the lining. During melting down, when the arcs can be buried in the charge and the heat absorbed, or in small furnaces, this change of temperature is not of great importance, but in large furnaces, or during refining operations, a cold furnace bottom is one of the things the melter most dislikes. Considerable money has had to be spent on such furnaces in heating up the hearths with oil or gas before putting in even a molten charge; otherwise, the metal tends to solidify and segregate out contained alloys on the cold part of the furnace hearth.

In the large "Greaves-Etchells" furnace heat is applied in three ways, entirely over the furnace—but with more electrodes—giving better heat distribution, by change of switch, through top electrodes, by the heat generated in the charge by its resistance, and underneath the charge by the resistance of the lining to the flow of current. The lining is just a solid thick magnesite or magnesite-dolomite hearth rammed and baked in over a flat copper plate lying on the shell of the furnace. There are no studs of carbon or steel coming through and it is just as solid and durable as any other basic furnace lining. The heat generated by its resistance to current is always immediately taken up by the charge. This small amount of heat generated under the charge is sufficient to prevent skulling or sticking on the furnace hearth and also gives rise to convection currents, ensuring thorough mechanical mixing of the charge, uniform temperature throughout the bath and generally overcomes one of the most serious objections to the large electric furnace. Operation of two 20 to 25 furnaces over several years has shown that these are facts, not theories.

In working out the design and system of the "Greaves-Etchells" furnace, careful consideration was given to the fact that the ideal way of heating any material is by induced currents in the metal to be heated, and following that of heat underneath rather than on top of the charge.

Data on all existing induction types of furnace were thoroughly examined and practical tests made, but it was decided on many grounds—electrical complications, difficulty of charging and changing slags, trouble with refractory linings, high cost, expert attention need on such furnaces—that the induction furnace could not be put forward as a rugged, strong, workshop job, to compare in general utility even with the top electrode furnace. Subsequent costly failures of many types of induction furnace have verified the assumptions then made and although considerable improvements have been made recently, the induction furnace is not likely to ever be a serious competitor for standard melting.

The induction furnace not being feasible, and keeping in mind the main requirements of a new furnace, viz., a

*President Electric Furnace Construction Company, Philadelphia, Pa. Paper presented at the Spring Convention of the A. I. E. E., Pittsburgh, Pa., April 24-26, 1923.

balanced electrical load, higher power factor, better control of electrode arcs, less reactance, heating in the charge itself and underneath, the inventors after several years of experiment were able to put forward the "Greaves-Etchells" furnace. One of the most difficult problems was to get heat in and under the charge instead of merely over the metal to be melted. Experience with previous furnaces, notably the French "Girod" and the Swedish "Gronwall Elektrometall" furnaces, showed grave objections. The Girod furnace had a number of water-cooled steel studs projecting through the furnace hearth, and although this four-electrode furnace, in which the electrodes are all connected in parallel to the same pole of the electric supply with steel studs in the hearth, making electrical contact with the molten steel, gave better electrical conditions than a series-arc furnace like the Heroult,

ages and windings a balanced load is obtained for any hearth resistance. This can be mathematically proved by vector diagrams and oscillograph curves. The designs and arrangement also permits of independent control of each of four or more electrodes and render possible the multiplication of the number of electrodes and consequently of the size of the furnace.

In starting up a "Greaves-Etchells" furnace with a cold charge of scrap iron, the electric current first arcs over the metal, then passes through the whole mass of material and heats this by small arcs at all the poor contacts throughout the mass. The electric current passes right through the steel instead of merely skimming the surface as it would be expected to do in a series-arc furnace.

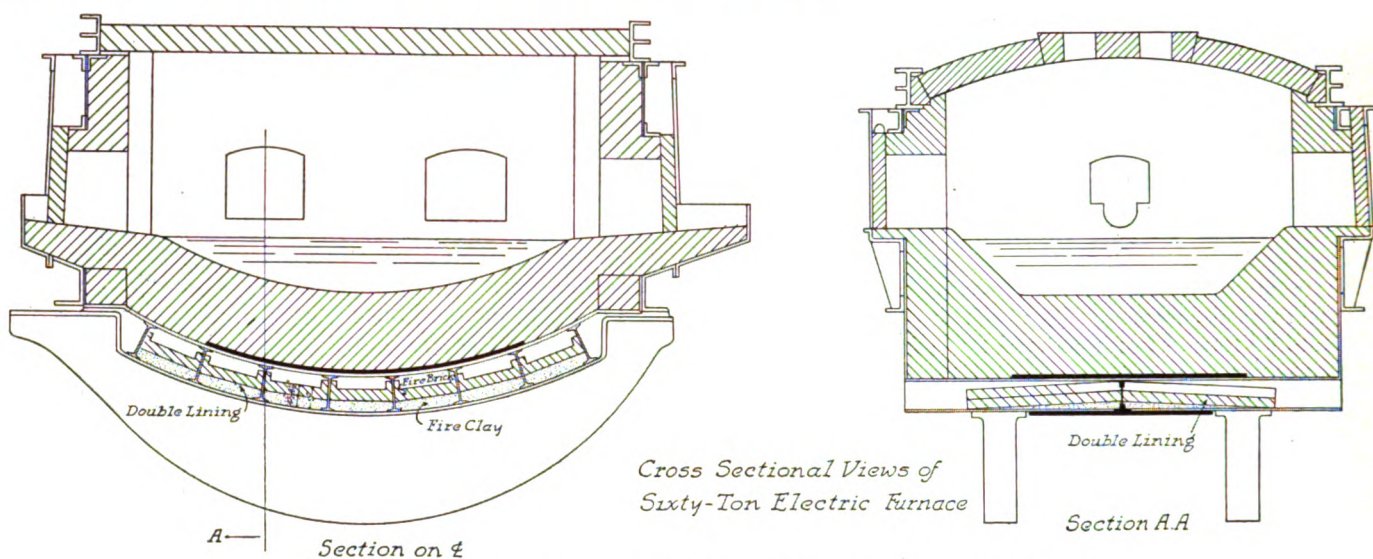


FIG. 1—Cross-sectional views of 60-80-ton furnaces building at River Rouge.

yet there were serious objections in induction losses and also the fact that all the bottom heat was concentrated to four steel points in the lining. The intense local heat caused expansion and contraction of refractories around the water-cooled studs and trouble invariably followed. It was therefore decided that the Greaves-Etchells lining must be solid and not pierced by studs of any kind.

One of the objections to the "Elektrometall" furnace with bottom conducting hearth was that the furnace is really a two and not a three-phase furnace, and although by means of a Scott-connection a better balanced load might be obtained than on a three-electrode series-arc furnace, it was felt this was an unnecessary complication. Another grave objection was that the furnace bottom was bound to be thin and highly conductive, as it was not connected to any leg of the power, but only to the neutral point.

The "Greaves-Etchells" furnace was designed with a thick resistive lining, and generated heat over the charge, in it by its resistance, and under it by resistance of the lining. This was achieved by attaching one of the three phases to the whole of the furnace hearth. This gave the power to force current through almost any thickness of solid lining and the lining could be made highly resistive where it was in contact with the charge. At the same time, to achieve a balance in all three legs, the secondary winding of the leg connected to the furnace hearth differs from that of the upper electrodes. The metal and hearth resistance is decidedly less than the resistance of the top arcs and so by suitably designing the bottom volt-

The furnace as finally developed may be described as an arc-resistance furnace, which on normal operation introduces two phases of the three-phase power supply line through two or more top electrodes and the third phase through the whole of the furnace hearth. On all recently installed "Greaves-Etchells" furnaces with four or more electrodes, the system and design permit of the whole of the power being put through top electrodes or by change of position of an oil switch through top electrodes and the furnace hearth, a balanced load being obtained with either method. This arrangement gives the furnace considerable flexibility of operation, as top electrodes and high voltage can be used when melting down or when starting up cold furnace, and the top and bottom contacts when molten bath is obtained or for refining and superheating.

It will be seen that the "Greaves-Etchells" furnace is not limited in size or in number of electrodes, as each group of two or four, with or without hearth connection, constitute electrically a separate furnace unit, and any multiples of two or four electrodes are quite feasible. The 60 to 80 ton furnace under construction for the Ford Motor Company has four banks of transformers, each of 3,000 kv-a. These are just as satisfactory and safe as four separate furnaces would be, and the power input will be so introduced that a stoppage of one, two, three or even four electrodes will not necessarily mean a furnace shut down. Each electrode will operate independently, so stoppage of arc on one electrode will not break the other arcs. The four, six and eight

electrode furnace offers more scope for correct mechanical design of large furnaces than three electrodes in a circular shell and the heat distribution from the top arcs is much better.

The fact that the number of electrodes can be increased indefinitely on the "Greaves-Etchells" furnace without electrical or electrode complication is removing some of the previously accepted ideas as to limit in size of electric furnace, and if the reader is earnestly informed that it is not safe or desirable to build electric furnaces larger than, say, 30 to 40 tons, it may be depended upon, it is because the design and system that would be employed is limited.

The advent of the Soderberg continuous electrode, now operating on a number of electric steel furnaces, may also have considerable bearing on future design of large electric furnaces. It consists of a thin metallic casing the size of the electrode to be used, into which the electrode paste or mix is dropped. This can be made up either over the furnace, or as is now done on most steel melting furnaces fitted with the Soderberg, by jointing up outside the furnace from 12 to 18 feet of casing, filling with the mix and putting into existing electrode holders, the actual baking of the electrode being done in the furnace. The cost is the mix, plus thin metallic casing, against finished extruded baked electrodes. Actual electrode consumption is considerably less, as the electrodes are protected by metallic casing and there are no broken electrodes, butt ends, etc. The size of this electrode is not limited by the size of the largest extruding press and electrodes either solid or hollow can be built far larger than called for in any existing furnace. By use of such electrode, the design of holding capacity of the large 3-top-electrode furnace can be more than doubled, although it would still have some of the inherent electrical and metallurgical defects of such furnaces.

Fig. 1 shows a diagrammatic plan and elevation of the 60 to 80 ton furnace designed for the Ford Motor Company, River Rouge Plant, Detroit, and now under construction. It will be equipped with eight electrodes and transformers of 12,000 kv-a. capacity. The electrodes are arranged in two rows of four, and each pair and contact plate under the hearth of the furnace—which is common to all—form an electrical unit and is supplied by a 3,000 kv-a., 3-phase transformer with the connections as detailed. By means of switch, power can, if desired, be put entirely through the top electrodes. When this is done, the bottom connections are thrown in series and consequently no current can flow through the hearth. As the additional current which would ordinarily flow through the hearth is distributed over the transformers and thence to the electrodes, the efficiency of the furnace is not altered and a balanced load is still maintained.

This furnace therefore has a much greater flexibility of operation than any existing furnace of large size—the top operation can be used in starting up a heat and by change of a switch heat applied underneath for getting the circulation in the bath necessary for quick refining.

The furnace has inside dimensions of 20 ft. 6 in. by 16 ft., built up of one-inch plate. Two rockers of heavy cast iron section form the main supports and these are assisted by 12-inch I-beams placed 27-inch centers. The rockers are so placed that the two upright channel columns in the rear rest directly on the rocker bearings. The furnace has a double lining with air space between. Fig. 4 illustrates general design and lining. The furnace is designed on open hearth lines, has fire doors, giving access to all parts of furnace, and tilts endwise. All doors are

operated by air cylinders, having a definite stroke to prevent overtravel. Side walls of furnace are 12 inches thick and the rear wall is given a slight arch. Roof bricks are 12 inches thick, but are thickened somewhat around the ports.

The special electrode economizers developed by the Electric Furnace Construction Company and fitted on the existing "Greaves-Etchells" furnaces at the Ford Motor Company will again be used on the large furnace and on the two 10-ton furnaces.

For tilting the furnace a 65-hp. motor is used. A double spur gear reduction operates a horizontal screw, which is placed under center of the furnace. The screw moves a nut to which are fastened two connecting rods, in turn fastened to a heavy casting bolted to beams under furnace. Screw and nut are enclosed in an oil tight housing and operate in an oil bath. Limit switches are provided to prevent overtravel.

The whole of the tilting mechanism and under part of furnace is protected in case of a run out by a double lining consisting of plate work covered with firebrick, lying under the proper furnace shell. This lining slopes from the center outwards.

The electrodes and motors are carried on a top platform above the furnace, supported by six vertical channel columns with horizontal supporting beams. These main supports are suitably tied together, braced by structural members, and covered with steel plate, on which electrode motors and gearing are placed. The electrode holders are hung by two steel chains passing over sheaves to winding drum and have insulated guide rods. This top arrangement of gearing, motors, etc., leaves the furnace body clear for metallurgical operations and enables the actual furnace shell to be designed solely for holding metal.

The furnace is designed to operate on a variety of voltages and with such heavy currents it has been necessary to pay special attention to interlacing the copper bus bars from transformers. Flexible copper strips carry current from the interlaced terminals to electrodes.

The whole of the switchboard, control equipment, automatic regulators, oil switches, transformers, etc., are located under the furnace stage level and the only electrical equipment showing above furnace stage will be two control pillars fitted with vari-colored lights. The electrical layout and installation is quite unique and reflects great credit on the engineers of the Ford Motor Company who were responsible for this.

The new plant at the Ford Motor Company also includes two 10-ton "Greaves-Etchells" furnaces, each with four electrodes and 3,000-kv-a. transformers, but no description of these will be attempted in this article beyond saying that these, like the 60-ton furnace, are so designed that they can operate either as acid or basic, with power either entirely through top electrodes or merely by change of position of oil switch with power through top electrodes and the whole of the furnace hearth.

The furnace hearths are quite solid, with no studs, water cooling or embedded electrodes; the whole of the hearth acts as a huge electrode if power is put through it by the switch arrangement previously mentioned.

The operation of the Ford furnaces will, in the writer's opinion, mark a new advance in the science of steel making and prove that the scope of the electric furnace is not confined to small melting furnaces for high grade steels, but can economically be an essential part of the process of making all steel.

Pump Suction

With Special Reference to Pumps for By-Product Plants for Handling Various Substances, Such as Water, Ammonia Liquor, Tar Wash-Oil, Etc.

By F. H. SMITH

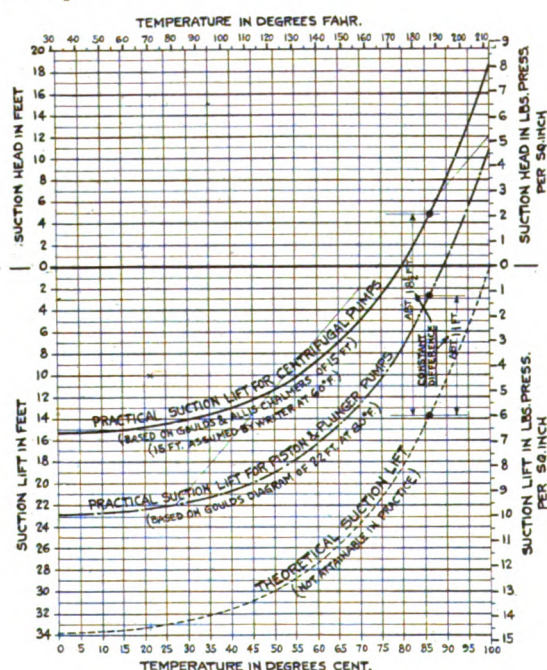
THE principal pump installations for by-product coke plants and which will be considered in this study, are for:

- (A) Water—hot and cold.
- (B) Ammonia liquor—weak and concentrated.
- (C) Tar—flushing, hot drain and sales.
- (D) Wash oil—hot and cold.

In addition to the preceding, there are the following, which though not strictly pumping propositions, are of that nature. They will not, however, be considered in this study.

- (E) Gas—exhausters and boosters.
- (F) Air—Compressors.
- (G) Acid ejectors—Operated by steam or air (See note "A").
- (H) Sulphate ejectors—Operated by steam or air (see note "A").
- (I) Boosters—For lifting liquids by compressed air.

Note "A"—When acid or sulphate ejectors are operated by air, they fall under the classification of "Air-Lift Pumps".



DIAG. 1—Gives the total net head available for different types of pumps.

Explanation, Diagram 1 (See item 6 of text)—The values in the diagram are reduced .117 ft. for every 100 ft. above sea level. For vapor pressures see Diagram 2.

P = absolute vapor pressure of water in lbs. per sq. in. at any particular temperature per Diagram 2.

$$S = \text{theoretical suction lift corresponding to "P"} = \frac{14.7 - P}{.434}$$

(Note: If "S" comes a minus quantity the suction is feet-head instead of feet-lift.)

2—This study is with particular reference to the "suction" for water, ammonia liquor, tar and wash oil pump installations, but the methods and data are of general application. No pump installation can operate successfully and deliver 100 per cent pump capacity with proper power consumption unless the suction is properly designed. Everyone recognizes the importance of having the suction as short and direct as possible and that in the case of very hot water, for instance, that the very hot water must flow to the pump. However, even though these conditions are recognized, the theory involved, as applied to pump suction, is little discussed in text books, catalogs, etc., and in consequence may be little understood by other than pump experts, and therefore, not given proper consideration, unless special study is made for a particular installation by the manufacturer of a line of pumps especially adapted to that installation, such as pumps for tar, and his recommendations followed. It may be that a certain pump, as far as the pump itself is concerned, is suitable for cold water or cold tar but it does not necessarily follow that the diameter of suction opening on the pump is the proper diameter of suction pipe for tar although it may be and probably is proper for cold water, the proper procedure in this case would be special consideration of the suction if the pump is to handle tar, which case it would probably be found that a larger diameter suction pipe is required than the diameter of the suction opening on the pump, requiring a reducer from the suction pipe to the pump.

3—The various types of pumps may be broadly classified as piston, plunger, rotary and centrifugal, each has its special field but all over lap to a greater or less extent and it is well to be guided by those experienced when selecting a pump for a particular service. If sufficient and correct physical data (see "4") is available and the theory involved is given proper consideration in connection with the physical data, there is no reason whatever why the installation should not be a success. No one, however, cares to place pumps in pits below ground level or floor level, if avoidable; neither does one care to place pumps in pits to play safe; what is desired is what is proper for any particular condition. The writer is aware of an installation of several tar pumps in which every pump proved unsatisfactory and in which particular pumps were nearly absolute failures. This was probably due to the manufacturer having been furnished insufficient or incorrect physical data or else because the installation was made by the purchaser without sufficient or correct physical data considered in connection with the theory involved, for certainly the manufacturer of these pumps could justly claim to be experienced in handling such materials as tar, etc.

4—Besides the proper allowance for resistance of the length of suction line; the foot valve and strainer, if used; elbows, tees, etc., the physical data referred to in item "3" must also be properly considered, if the

total available suction developed by the pump is not to be exceeded. The physical data is:

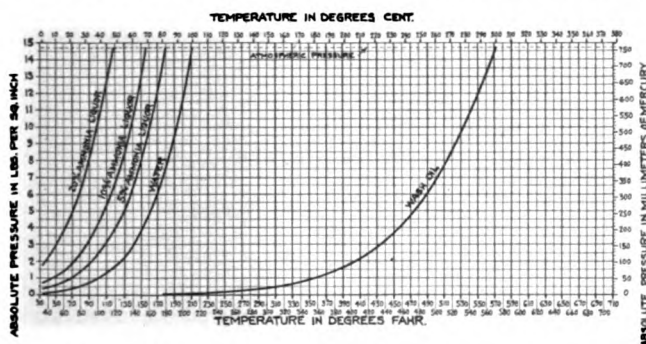
- (A) Temperature of the material to be handled by the pump, and at any particular temperature, the
- (B) Weight per cu. ft.
- (C) Vapor pressure, and
- (D) Viscosity.

The suction that any particular pump under any particular conditions of operation, such as speed, etc., will develop will be stated by the manufacturer (see "6"—see Diag. 1), for a pump in good condition; the suction that the pump will develop will be decreased due to the vapor pressure of the material being pumped (see Diag. 2), and the net available suction after allowing for the vapor pressure of the material is the suction available for producing flow of the material to the pump.

5—While, as previously stated, this study is with particular reference to the suction, it may be well to call attention to the following:

- (A) The pump parts should be of a material to best withstand the chemical action of the material pumped.
- (B) The total lift or head includes the suction lift as well as the discharge head.
- (C) Valve should be placed in the suction and discharge lines at the pump, to isolate the pump.
- (D) Consideration should be given to a by-pass from the discharge to the suction side of the pump.
- (E) Priming the pump.
- (F) Air chambers on discharge (and suction sides) of pump.
- (G) Air (or vapor) "pockets" in the suction and discharge piping should be avoided if possible, otherwise means for venting should be provided.

E. A. Moritz, in "Working Data for Irrigation Engineers," page 69 of First Edition, first thousand—1915 (published by John Wiley & Sons) states: One of the most important features in the design of pipes to



DIAG. 2—Vapor pressures at varying temperatures for various substances.

Explanation, Diagram 2 (See item 7 of text)—Ammonia liquor curves developed from Table P-632, and curves P-495, book of reference "E. E."

Wash-oil curve developed from Table P-131, Book "F. F."

Water curve developed from Table P-172, Book "G. G."

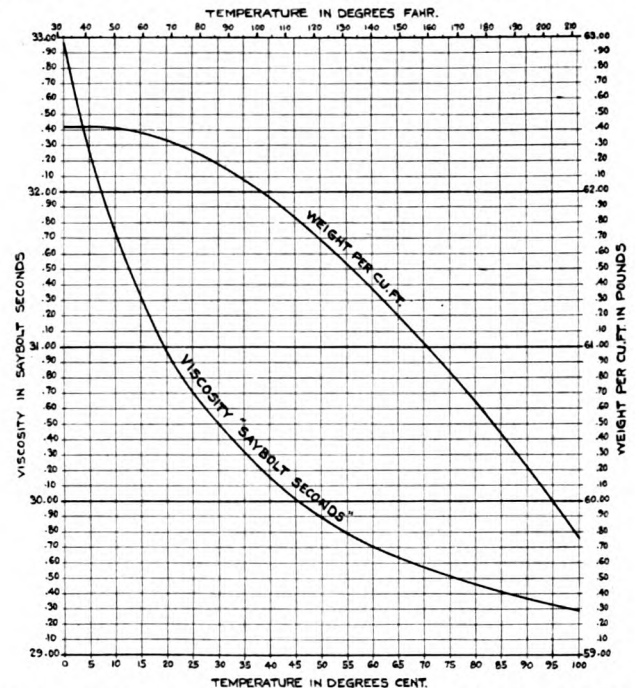
See tables for vapor pressure of water for temperatures higher than 212 deg. F. or 100 deg. C.

operate under pressure is to make provision for preventing the carriage of air through or accumulation of air in the pipe, as the presence of air in a pipe decreases the capacity in a marked degree.

See also "Hydraulics" by R. L. Daugherty, page 105, second edition, fourth Imp., McGraw-Hill Book Company; "Kents Mechanical Engineers' Pocket Book," page 722, eighth edition; "Mark's Mechanical Engineers' Pocket Book," page 1737, first edition, fourth Imp.

Suction Lift Developed by Centrifugal Pumps.

6—(a) The Goulds Manufacturing Company's Bulletin No. 112, "Hand Data on Power Pumping" (seventh edition, page 20) states: "We guarantee our



DIAG. 3—Viscosity of water in saybolt seconds, also weight per cubic foot of water at different temperatures.

Explanation, Diagram 3 (See item 8 of text)—Viscosity curves developed from table on P-262 of book "A. A," formula 7 in 8-9 of text.

centrifugal pumps where the suction line is properly laid out and air tight to lift the full rated capacity to a total net head of 15 ft. maximum. This total net head consists of the actual suction lift plus pipe friction in the suction line (including foot valve and strainer) and velocity head. Under perfect conditions, 22 foot lift and even more may be obtained, but the capacity is apt to be less than the rated capacity under a moderate suction lift. (Always place the end of the suction pipe at least 3 ft. below the surface of the water in the suction well to prevent air being drawn into the pump. The pipe should slope downward to the suction well and never upward, if there is any suction lift. The Goulds Manufacturing Company's Bulletin No. 122, second edition, page 23, "Centrifugal Pump Sales Service Data"; Allis-Chalmers Manufacturing Company's Bulletin No. 1632 C, "Centrifugal Pump and Centrifugal Pumping Units," sixth edition, page 44, states: "The highest permissible lift, including friction, is about 22 ft. while the basis for guarantees is usually made 15 ft. which means that the pump should be placed if possible not over 12 ft. above low water level in the suction well, and the suction should be submerged 4 ft. if possible."

Suction Lift Developed by Rotary Pumps.

(b) The total net head lift of a rotary pump for

its full rated capacity will no doubt depend upon the particular make of pump and manufacturers should be requested for their guarantee. (See "6-a").

Suction Lift Developed by Piston and Plunger Pumps.

(c) The Goulds Manufacturing Company's Bulletin No. 112, "Handy Data on Power Pumping," seventh edition, page 20, give the information (by diagram), for water, that the suction lift at sea level is 22 ft. at 80 deg. F. and the suction head at sea level is 12 ft. at 212 deg. F. (the diagram from which this was taken connects up these two points with a straight line, which gives a less total net head between the two points than, according to the writer, is justified. The writer believes that the line of "practical suction lift" of the diagram should parallel the line of "theoretical suction lift" beginning at 22 ft. lift and 80 deg. F. and ending at 12 ft. head and 212 deg. F. and it is so shown on Diag. 1.

The Union Steam Pump Company's "Union Engineering Handbook," first edition, page 286, gives the information (by diagram) for water, that the suction lift is 24 ft. at 0 deg. F. and the suction head is 10 ft. at 212 deg. F. (the diagram from which this was taken connects up these two points with a straight line similarly as by the Gould Manufacturing Co., to which the writer takes exception—read in parenthesis of "6-c").

Read over "Suction Lift for Centrifugal Pumps"—"6-a".

(d) Diag. No. 1 gives for water at different temperatures the total net head available for different types of pumps for full rated capacity based upon the preceding discussions; Diag. No. 3 gives the vapor pressure of water corresponding to the temperature.

Vapor Pressure.

7 To determine the net available suction for producing flow of the material to the pump (total net head available less vapor pressure) for any substance other than water Diag. 1 and Diag. 2 may be used. Assume a 5 per cent ammonia liquor at 70 deg. F., at about 850 ft. above sea level; from Diag. 2 the vapor pressure of a 5 per cent ammonia liquor at 70 deg. F. is the same as the vapor pressure of water at 110 deg. F., for which Diag. 1 gives an available suction lift of about 13.2 ft. at sea level, for centrifugal pump, and for about 850 ft. above sea level a net available suction lift of $13.2 - .117 \times 8.50 = 13.2 - 1.0 = 12.2$ ft.

8—(a) Viscosity is one of the most important consideration entering into pumping propositions. There are many cases where the material to be pumped is so viscous at ordinary temperatures that heating must be restored to; the material being heated either before entering the suction piping, during its passage through the suction piping, at the pump (steam jacketed pump), or in the discharge line (during its passage through the discharge line, or at certain points) or various combinations of these.

(b) Viscosity is the degree of fluidity of a substance, its internal frictions or shearing modulus. The Saybolt Universal Viscosimeter is commonly used in this country to determine viscosity by noting the time in seconds required for a certain quantity of fluid to flow through an orifice at standard temperatures. Another instrument for determining viscosity is the Doolittle Torsion Viscosimeter. (Page 645, Bk. Ref. "BB".) (See also page 1247 of Bk. Ref. "BB".)

In general it is found that viscosity increases with increasing weight per cu. ft. and with decreasing temperature. The relation of viscosity to weight per cu. ft. is, however, irregular in special cases and subject to occasional exception. With regard to the variation with temperature it is usually found, starting with high temperature, that the increase of viscosity is at first slow, the rate of increase rising rapidly as the temperature drops. (Page 247, Bk. Ref. "AA".)

(c) Viscosity may be stated in terms of poises, absolute metric (or C. G. S.) units, absolute English units, kinematic viscosity and, in terms of Saybolt, Engler, etc., seconds. Definitions and formulas for viscosity are as follows:

One poise = 100 centipoises = one absolute metric (C. G. S.) unit. (P. 249 Bk. Ref. "AA".) Formula (1).

The factors of the absolute metric (or C. G. S.) unit, (dynes per sq. cm. per second), and

The factors of the absolute English unit, (pounds per sq.ft. per second) are defined on p. 73 of Bk. Ref. "BB".

Kinematic Viscosity is the result obtained by dividing absolute viscosity in "poises" by the weight in grams per cubic centimeter (p. 9, Bk. Ref. "DD".) See also p. 1247 Bk. Ref. "BB".)

(d) Let u = absolute English viscosity

$= \frac{RZ}{y}$ in which "R" is the force opposing the

motion of a plane of unit area lying very near and moving with a velocity "y" parallel to a large plane, the space of thickness "Z" between the two planes being filled with the liquid in question (p. 246, 250, 257 Bk. Ref. "AA").

t = time in Saybolt seconds (by standard Saybolt Universal Viscosimeter) (Table "3", p. 7, Bk. Ref. "DD").

a = weight in pounds per cu. ft.,

then $u = a \left(.00000237t - \frac{.00194}{t} \right)$ Formula (2)

(From p. 250, Bk. Ref. "AA".)

(e) Absolute metric viscosity may be determined from absolute English viscosity and vice versa by the following formulae:

Let M = absolute metric viscosity
 $= 14.88 u$ Formula (3)

and $u = \frac{M}{14.88}$ (P. 249, Bk. Ref. "AA".) Formula (4)

(f) Let K = Kinematic viscosity
 $= \frac{P}{G}$, in which "P" is the absolute viscosity in "poises" and "G" is the weight in grams per cubic centimeter (p. 9, Bk. Ref. "DD").

t = time in Saybolt seconds (by standard Saybolt Universal Viscosimeter) (Table 3, p. 7, Bk. Ref. "DD").

then $K = .0022t - \frac{1.80}{t}$ Formula (5)

(From p. 19, Bk. Ref. "DD".)

and $P = KG$

(g)

Let t = time in Saybolt seconds (by standard Saybolt Universal Viscosimeter Table 3, p. 7, Bk. Ref. "DD".)

$$= 227K + \sqrt{818 + (227K)^2} = 227K + \sqrt{818 + (227K)^2}$$

Formula (6)

$$= 201,970Q + \sqrt{818.5 + (201,970Q)^2}$$

Formula (7)

 $Q = \frac{u}{a}$ in which "u" is the absolute English

viscosity and "a" is the weight in pounds per cu. ft.

value of "u" (= absolute English viscosity) at 100 deg. F. for a coke plant tar having a "specific viscosity" of 7 (by standard Saybolt Universal viscosimeter) at 100 deg. F. Frog Diag. No. 3, water at 100 deg. F. has a viscosity of 30.23 Saybolt seconds, therefore tar will have a viscosity of $30.23 \times 7 = 211.6$ Saybolt seconds at 100 deg. F. We will assume the tar to weigh about 73 lbs. per cu. ft. at 100 deg. F. (Sp. gr. about 1.17) from which (by Formula 2 of item "8-d").

$$u = 73 (.00000237 \times 211.6 - \frac{.00194}{211.6})$$

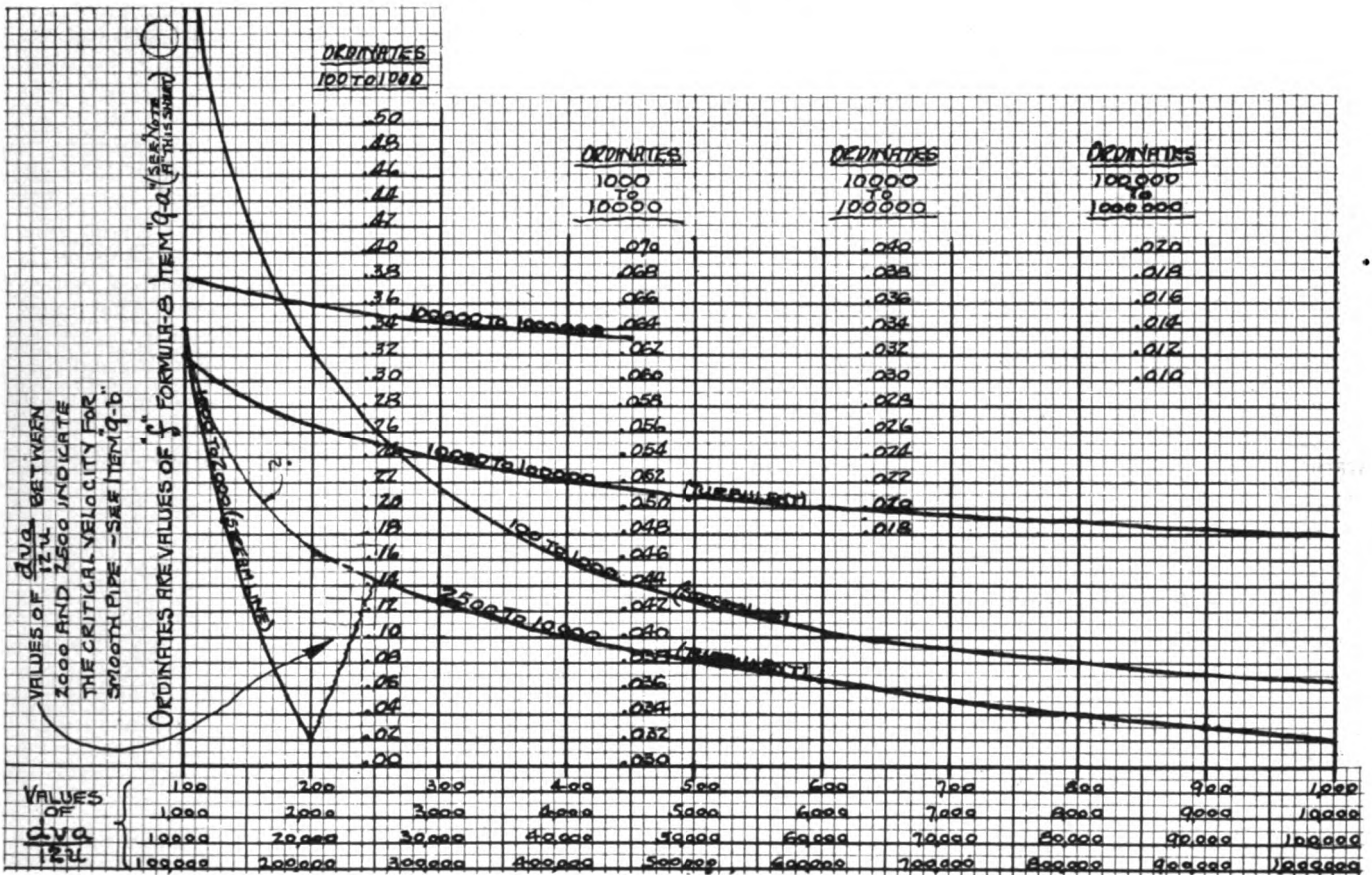
$$= 73 (.00050149 - .00000917)$$

$$= 73 \times .00049232$$

$$= .036$$

Flow of Liquids in Pipes.

9—(a)



DIAG. 4—Curves plotted from table 32, book of references "AA."

Note: Formula 6 was derived from Formula 5 in "8-f". Formula 7 was derived from Formula 2 in "8-d".

(h) The term Specific Viscosity means the ratio of the viscosity of the fluid under consideration to the viscosity of water at a specified temperature. (Page 127 Bk. Ref. "CC".)

Diag. No. 3 gives the viscosity in standard Saybolt Universal seconds and the weight per cu. ft. of water at different temperatures.

From the preceding, if the viscosity is given in terms of one unit it can readily be determined in terms of any of the other units.

Formulae, to be given subsequently for determining flow of liquids in pipe include viscosity in terms of absolute English units, suppose it is required to find the

p = pounds per sq. in. pressure required to overcome resistance to flow for one lineal foot, or, which is the same thing, the loss of pounds per sq. in. pressure per foot length due to resistance.

$$= \frac{f v^2}{772d} \quad \text{Formula (8)}$$

This is formula "4", page 258, Book Ref. "AA" modified by F. H. S. to make "D" in inches; "G" in pounds per sq. in. and to eliminate "g" ("g" = 32.15).

(See next to last paragraph of "9—b" stating how "p" varies.)

f = friction coefficient in Darcy's formula

less suction lift than a centrifugal pump, we have an available suction lift of about 13 ft. for water at 70 deg. F. with a cycloidal pump at sea level. The installation being at 610 ft. above sea level the available suction lift must be decreased .117 ft. for every 100 ft. altitude (see Diag. No. 1) giving $13 - .117 \times 6.10 = 13 - .7 = 12.3$ ft. available suction lift.

(c) We will use the viscosity at 131 deg. F., that is 54 Saybolt seconds, (as the pump may be required to pump this oil cold), for which the absolute English viscosity

$$u = 56 (.00000237 \times 54 - \frac{.00194}{54})$$

$$= .005 \text{ [by Formula (2)]}$$

The velocity of flow

$$v = \frac{24000}{7.5 \times 60 \times 60} \div (8 \div 12)^2 \times .7854$$

$$= 2.54 \text{ ft. per second}$$

By formula $\frac{dva}{12u}$ item "9-b", we get

$$\frac{8 \times 2.54 \times 56}{12 \times .005} = 18960, \text{ which indicates a turbulent}$$

flow for a straight run of pipe; for which, from Diag. No. 4 we find that "f" in Formula (8) = .027.

(d) The loss of pounds per sq. in. pressure per foot of length due to resistance is—

$$p = \frac{.027 \times 56 \times 2.54^2}{772 \times 8} = \frac{9.75}{6176}$$

$$= .00158 \text{ lbs. by Formula (8)}$$

This piping is made up of various valves, tees, ells, etc., some of which, however, do not change the direction of flow; these ells, etc., are rough inside and have a different inside diameter than the inside diameter of the steel pipe; everything considered "p", as determined above, should probably be increased about 90 per cent, giving $.00158 + .00142 = .002$ lb. per sq. in. pressure to overcome the resistance to flow of one lineal foot of pipe.

(e) From Mark's Mechanical Engineering Handbook, 1916 Edition, page 275 and National Tube Company's Handbook, 1913 Edition, page 284, we get—

	Equivalent Length of Straight Pipe in Pipe Diameters	Equivalent Length in Feet of 8" Diameter Pipe	Number Used in This Installation	Total Equivalent Length of 8" Diameter Pipe
Long radius elbow..	10	6.66	7	46.62
Short radius elbow..	20	13.33	2	26.66
Tee	50	33.33	1	33.33
Gate Valve	6	4.00	2	8.00
Total				114.61
Actual straight pipe.....				35.23

$$\text{Grand total} \dots\dots\dots 150.00$$

say $150 \times .002 = .300$ lbs. per sq. in., total loss due to resistance of piping to flow (that is the pressure required to cause the flow)

.300 lbs. per sq. in. equivalent to one foot water head

$$\frac{.300}{.434} = .7 \text{ ft. water head to overcome the resistance to}$$

flow of 24,000 gal. hot wash oil per hour in the suction piping.

$$(f) \quad 12.3 \text{ ft.} = \text{available suction lift (as determined at beginning of item "10").}$$

$$.7 \text{ ft.} = \text{resistance of piping to flow}$$

$$11.6 \text{ ft.} = \text{net available water head}$$

The wash oil has a specific gravity of 0.898; therefore the net available suction lift for the wash oil at 293 deg. F., 610 ft. altitude, etc., is $\frac{11.6}{.898} = 13 \text{ ft. about.}$

We require a maximum of only 9 ft. in the installation (see sketch) so that there is a factor of safety of about 50 per cent.

References to Data on Vapor Pressure.

"Engineering Thermodynamics" (see Bk. Ref. "EE", page 495 and page 632) for Ammonia Liquors of various strengths.

"Elements of Fractional Distillation" (see Bk. Ref. "FF", page 6) for Water Vapor Pressure curve; page 31 for Benzene (C_6H_6); page 131, for Wash Oil; page 35 Partial Pressure of Ammonia over Water; "Handbook of Chemistry and Physics" (see Bk. Ref. "GG"), pages 172 to 174 inclusive for Water. "Smithsonian Tables" (see Bk. Ref. "CC").

References to Data on Pump Installations for Oil, Viscosimeters, Viscosity, Etc.

See Wayne Oil, Tank & Pump Company, Fort Wayne Ind., Bulletin No. 2, 8-5-20, for practical pointers regarding the piping for and installation of pumps for handling oils; also their Bulletin No. 150, 4-19-21, "Engineering Tables and Data" which gives the specific gravity of oils, loss of head in feet due to friction in elbows, etc. (See Schutte & Koerting Company, Philadelphia, Pa., Bulletin No. 12 C, 1921, "Heat Exchangers for Recooling Oil" which contains valuable information regarding viscosity of oils and viscosimeters; a diagram for converting Engler, Saybolt & Redwood readings to each other, etc.

See "Smithsonian Tables" (see book reference "CC") for Tables of Viscosity of Water; Alcohol and Water; Oils; Miscellaneous, including Ammonia and Phenol; Solutions; Gases; Vapors; Air.

References to Data Regarding Resistance to Flow by Valves, Elbows, Bends, Fittings, Etc.

"Book of Standards," National Tube Company, 1913—for water, page 183; steam, page 346; Gas and Air, pages 324 and 364; "Hydraulics of Pipe Lines," (see book reference "AA"), page 22 for "Loss of Head Through Gate Valves, Butterfly Valves, Plug Cocks"; page 23 for "Loss of Head Due to Bends, Elbows, Angles."

"Mechanical Engineers' Pocket Book" (see book reference "BB") page 275 for Loss of Head Through Curves, Elbows, Meters, Etc.

Book References.

(AA)—"Hydraulics of Pipe Lines" by W. F. Durand, published by D. Van Nostrand Company—1921.

(BB)—"Mechanical Engineers' Hand Book," Lionel S. Marks, Editor in Chief, first edition, fourth Imp., 1916, McGraw-Hill Book Company.

(CC)—"Smithsonian Physical Tables" — Sixth re-

(Concluded on page 330)

The Production and Utilization of Producer Gas for Heating Open Hearth Furnaces*

By M. G. HUSSON, Rev. de L'Industrie Minérale 2-373-406 (1922)

PART II

CHAPTER I

Practical Applications

In part one we have assumed chemical equilibrium between the gas and the coal but the gas producer is an apparatus in unstable equilibrium. Every irregularity of operation tends to exaggerate it and only by incessant poking can equilibrium be maintained. However, if the poking becomes too frequent or is improperly done it defeats itself, first, by making channels, second, in bringing incandescent coke to the surface; third, allowing cold coal to fall through and throw out of balance the various zones in the producer. It is, therefore, important after determining the optimum equilibrium conditions to see what practical factors influence attaining that equilibrium.

A coal too rich or too pasty gives a hard caking coke which causes trouble. For an ordinary gas coal containing 30 to 40 per cent volatile, it is safe to say, in general, that the higher the volatile the less sticky and therefore the better for producer work. However, the anthracites are especially good from this point of view; while the worst coals are the coking coals with 20 to 25 per cent volatile.

Coals with a high ash or a fusible ash are also poor for producer work, because clinker gives the same trouble as lumps of coke.

Large size coal is better than fines (fines are used in making coke) but they give poor distribution.

A wet coal makes distribution less easy and irregu-

Translated and condensed by Prof. R. T. Haslam and Mr. H. O. Forrest, Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

lar, cools off the bed of the coal and thus slows down distillation tending to form coke agglomerate.

The hotter the fire the less noticeable the cooling effect of the sides, the less regular the temperature distribution and the greater the tendency to channel, form zones too hot and thus fuse the ash. On the other hand, a fire too cold slows down distillation and tends to form more adherent coke. Also, according to Angles d'Auriac, the products of distillation do not remain the same for various temperatures and a cold fire means less cracking in the producer and more condensation in the mains to the furnace. This point is upheld by practice since the hotter gases usually have less CH_4 and more H_2 , which is not shown by our calculations.

Poor distribution in the producer makes the coal fall in heaps which heat slowly and thus have a chance to form adherent coke. The distribution of air may also be irregular and hinder good operation.

All these practical factors have great significance and explain many things, as does also the theory. Both must be used together to get useful results.

CHAPTER II

The results of Part I are shown in Table VII, lines 1, 2, 3 and 6 show the logic of classifying the gases according to the values of T and N. The values of T and N increase with the volatile matter and experience has shown that a high volatile coal gives better results. The only apparent anomaly is that this classification shows a long-flame lean coal inferior to a short flame rich coal when experience shows the opposite. However, this is not a reason for rejecting the theory.

TABLE VII

Kind of Gas	Flame Temp. T° F.	N Heat Utilizable at T° Btu. Per Cu. Ft.	L ¹ Heat Utilizable Btu. Per Lb. of Coal	Ratio of 100 L ¹ to Calorific Value of Fuel	Analysis of Gas Produced Water and Tar Condensed					Calorific Value Btu. Per Cu. Ft.
					CO ₂	CO	H ₂	CH ₄		
1 Gas from coke 1472°...	4055	4.19	5910	40.5	2.76	30.60	5.50		121.0	
2 Gas from rich short flame coal 1292°.....	4118	4.48	7380	47.5	6.70	24.80	14.65	1.90	145.8	
3 Gas from rich long flame coal 1292°	4190	4.72	7080	45.8	6.70	24.80	15.35	2.45	153.2	
4 Gas from rich long flame coal 1472° (tar disso- ciated)	4154	4.51	5890	38.3	2.56	28.00	12.15	2.38	154.2	
5 Gas from rich long flame coal 1472° (tar not dis- sociated)	4235	4.77	7060	45.7	2.65	28.90	9.05	2.45	149.0	
6 Gas from lean long flame coal 1292°	4178	4.70	6840	46.5	6.60	24.60	15.20	2.60	153.5	
7 Gas from rich long flame coal 1292° (tars con- densed in main).....	4086	4.44	5510	35.7	6.70	24.80	15.35	2.45	153.2	
8 Gas from rich long flame coal 1112°	3911	3.99	6050	39.2	14.30	14.00	21.40	2.10	130.4	
9 Gas from long flame coal 1472°	4176	4.43	5530	35.8	0.50	29.70	7.20	2.35	145.3	

TABLE VIII—INFLUENCE OF METHOD OF OPERATION ON CHARACTERISTICS OF PRODUCER GAS

Kind of Operation	Gas Analysis			Characteristics of gas		Appearance of Fuel Surface	Value of Gas Obtained and Causes of Poor Operation
	%CO ₂	%CO	%H ₂	Temp. ° F.	Appearance		
Cold Fire In Equilibrium	7-10	18-20	Over 15	1200 to 1300	Golden Yellow Much Tar	Dull Red or Pale Cherry	Very bad. Combustion too slow. Too much steam.
Cold Fire Not In Equilibrium	Over 7	Below 20	13-17	1200 to 1300	Golden Yellow Much Tar	Dull Red or Pale Cherry	Very bad. Combustion too slow. Upper part much hotter than lower. Too much steam or grate choked.
Good Fire In Equilibrium	4-6	About 24	About 15	1300 to 1500	Yellow Still much tar; often a little smoky from dissociated tar.	Cherry to Bright Red	Excellent operation.
Good Fire Not In Equilibrium	Over 4 or 5	Less than 24	15 or Less	1300 to 1500	Smoky Tar dissociated.	Cherry to Bright Red	Upper part much hotter than lower. Poor operation, not enough poking, coke too sticky, or too much fusible ash.
Hot Fire In Equilibrium	3-4	Over 25	5-10	Well above 1500	Smoky Tar entirely dissociated.	Bright Red to Pale Yellow	Not enough steam. Operation passable, and sometimes to be recommended with rich or low ash coals. Channeling changes this to next type.
Hot Fire Not In Equilibrium	Over 3 or 4	Less than 25	5-10	Well above 1500	Smoky Tar entirely dissociated.	Bright Red to Pale Yellow	Not enough steam. Too much ash or ash too fusible. Not enough poking. Very poor, about same CO ₂ as (2) but distinguished by low H ₂ .

The reason is probably found in the last chapter, i.e., equilibrium is easier to obtain with the lean, high-volatile coal. A classification based on L^1 and P^1 would give results contrary to practice. Classifications based on the ordinary calorific power are also of no use because they neglect the tar. For instance, gas No. 5 is better than that of No. 4 although the calorific power is lower.

The differences in calculated values are not so small that they are entirely outweighed by practical operating. For example the variation of N from coke producer gas to the optimum gas is 11.5 per cent. Also the heat transfer increases very rapidly with the temperature, so that a change of a few degrees is important. Again the gases which give the best theoretical results are also those most easy to handle in practice.

From all these considerations, we will call a good gas one where T is at least 4170 deg. F. and N at least 4.7 Btu.

An examination of Table VII, assuming this method of classification, shows the optimum operating temperature to be between 1300 deg. F. and 1500 deg. F. and it may vary between these limits for different cases. In going from 1300 deg. F. to 1500 deg. F. there is a gain in the coking zone and a loss in the distillation zone. Occasionally it is better to operate a little above 1500 deg. F., sacrificing theoretical loss for practical gain in operation. The conclusions are that a hotter fire must be maintained for a rich coal, and that a lean coal is superior to a rich one. These conclusions are confirmed in practice. Also the more fusible the ash and the less the volatile, the lower the allowable ash in the coal. There is less theoretical loss in operating too hot than too cold, even though the hot gas is less apt to be in equilibrium, because the equilibrium for the cold gas is in itself very poor.

By operating hot we mean that the gas should be in equilibrium at the higher temperature and not that the hot gas shall be formed by channeling and burning of the CO to CO₂ in the top of the producer.

There is a definite quantity of steam necessary for given operating conditions. If, when this quantity is used, the ash is not broken up, no more steam should be used, but the remedy lies in poking more effectively.

The problem of coal distribution is most important when the fuel is rich and has a coking tendency.

A resume of the effect of various firing temperatures with the characteristics of the gases obtained is given in Table VIII.

PUMP SUCTION

(Continued from page 327)

vised edition, third reprint, 1918—Frederick E. Fowle, published by the Smithsonian Institution.

(DD)—“Technologic Paper No. 112 of the Bureau of Standards.

(EE)—“Engineering Thermodynamics” by Lucke, first edition, third Imp., 1912, McGraw-Hill Book Co.

(FF)—“Elements of Fractional Distillation” by Clarke Shove Robinson, first edition, second Imp., 1922, McGraw-Hill Book Company.

(GG)—“Hand Book of Chemistry and Physics,” fifth edition, 1917, Chemical Rubber Company, Cleveland, Ohio.

“Holding on to Prosperity”

Secretary Hoover has the facility of genius in his timely appeals to Americans. In his speech before the U. S. Chamber of Commerce, New York City, May 8th, he summarized the prevalent attitude of mind in four words, “Holding on to Prosperity.”

Caution should not be confused into timidity, the present situation is entirely different from 1920—“We must get our minds away from the notion that pre-war standards of living and volume of business would be normal now.”

The efficiencies of production have risen 10 to 15 per cent per capita. “We could today supply each person the same amount of commodities that he consumed 10 years ago, and lay off 2,000,000 people from work.”

Essential considerations now are “the strategy of business in the method of handling our vast gold reserve, the tremendous need for increased private construction, retardation of public works, a definite policy in agricultural exports—further efficiency in production and distribution, more careful consideration of the effects upon future production costs which the shortage of transportation and intermittent coal industry impose. Citing examples of elimination of waste, “I have recently received a statement from one single group, estimating that savings in production in that trade exceed \$25,000,000 annually.”

Requests to the Department of Commerce for business assistance, advice and information have risen in 18 months from a few hundred daily to more than 3,000 daily.

Government has a definite relationship to the advance and maintenance of prosperity. “Not as an agency for production and distribution of commodities, nor as an economic dictator, but as the greatest contributor in the determination of fact and of co-operation with industry and commerce in the solution of its problems.”

“The preservation of initiative and the safeguarding of the rewards of individual effort, character and ability are keystones,” the Secretary said, which must be preserved, “for when all is said and done the finer flowers of civilization do not grow from the cellars of poverty any more than they grow from the palaces of extravagance. They grow from the bettering comfort and well-being of the whole of great peoples.”

The Tonawanda Iron Company, Buffalo, N. Y., recently organized by officials of the American Radiator Corporation, has taken over the two blast furnaces of the Donner Steel Company at Tonawanda, N. Y., and will make a number of improvements in the units. The furnaces have been idle since the close of the war; one stack, 18x78 feet, was rebuilt in 1918, and the other, 18x80 feet, was constructed in 1895. The two units have an annual rated capacity of 180,000 tons of pig iron, and were secured by the new company for a consideration said to be in excess of \$1,500,000. The stacks will be remodeled and relined and will be placed in blast at an early date on pig iron, producing exclusively for the parent organization, which will use the output at its foundries in different parts of the country. The Tonawanda Iron Company is capitalized at \$1,500,000, and is headed by John W. Van Allen and William R. McConnell.

The Eagle Iron Works, Court and Third Streets, Southeast, Des Moines, Ia., has preliminary plans nearing completion for the construction of a new two-story and basement plant, 80x275 feet, estimated to cost approximately \$100,000, with machinery. W. B. Holtzman, Jr., 406 Flynn Building, Des Moines, is architect.

THE SAFETY CRUSADE

Human Beings DO "Fall Down"

Safety Devices Are Necessary, Not Because Machines Are Dangerous, But Because Human Beings Are Less Reliable Than Machines

"I WOULDN'T be alive today if it hadn't been for that guard," said Foreman Bill to the Big Chief, as they looked at the swiftly revolving flywheel enclosed by a stout wire cage. "I was standing right in this very spot when a circuit breaker blew out over on the board. I started for it quick, slipped on a small spot of oil and landed up against that guard. Lucky for me it was there."

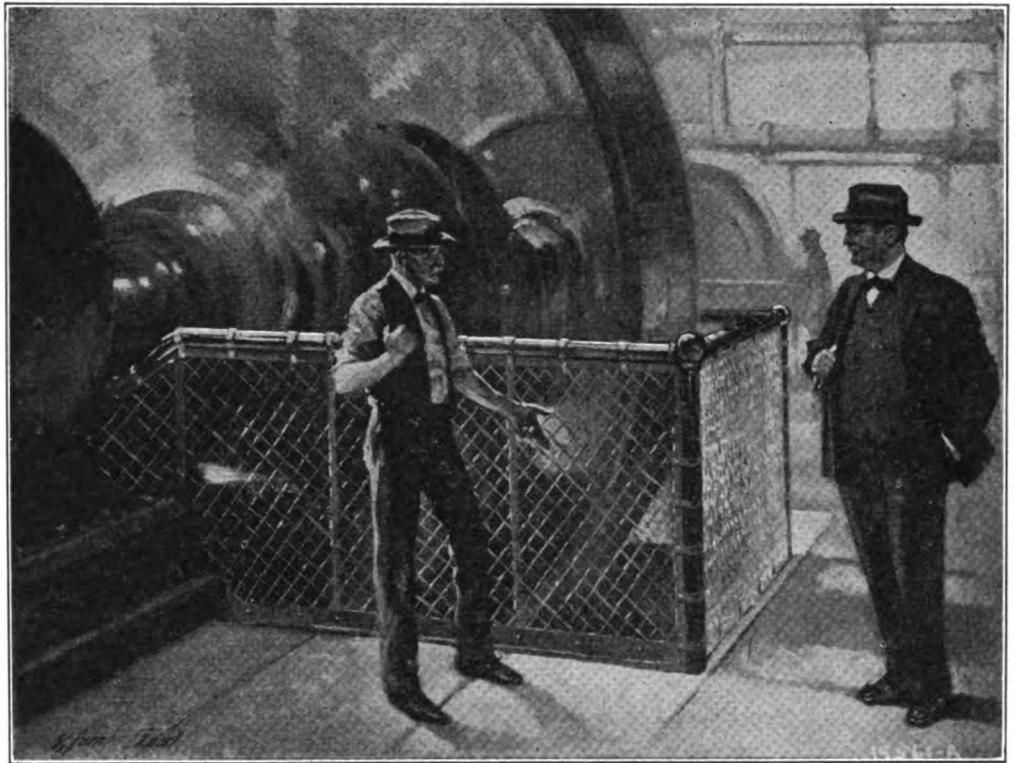
One might say, "Well. Bill should have watched his step. What was that oil doing there, anyway? A man can't be too careful around dangerous machinery." But the fact still remains—Bill slipped and the guard saved his life.

Next to a careful man, the best safety device in the world is a good guard. We can put guards on machinery, but we can't put guards on men's brains. We generally know what a machine will do, but we can never accurately determine what tricks our minds will play on us to cause trouble. And that's why certain gears, belts, and other equipment in the plant generally must be covered up.

If we were as sure of what we will do tomorrow as we are of what the machines in the plant will do, we could throw away a large number of the safeguards now being used. There's the trouble! We don't know what moment some careless act or thought on our part will result in an accident.

Man suffered few accidents from the hand operated jack-knife, saw and hatchet, but when he created machines to cut wood, iron and steel he had to protect himself from them. Many a man has taken off a guard, saying, "That's the bunk," and has gone on working—and probably he has gotten away with it. But in the files of the National Safety Council are accounts of hundreds of accidents which happened because the guard was taken off, goggles thrown aside, gloves discarded, or some other safeguard ignored. On the other hand there are also on record numberless instances where accidents have been averted by means of guards.

The safeguards in our plants, in our power houses, in our streets, at our crossings, are intended to save lives, limbs and misery—they have a humane purpose we cannot afford to overlook. And no person has reason to believe that he can go through life and neglect these safeguards which have been developed for his protection.



Safety Door Latch

Many bad accidents have been caused by internal boiler explosions blowing out flame, gas and burning fuels through unlatched doors.

The National Board of Fire Underwriters have recently tested a simple latch device which prevents such accidents.

The latching faces of both the keeper and the latch-arm are vertical instead of slanting. All parts are steel, while the weight at the top of the latch-arm, which forms the handle, provides a positive latching force.

The industrial commissions of many states have approved the device.

Kinney and McDermott Awarded Prize

Mr. Charles L. Kinney, Jr., superintendent of No. 1 Open Hearth, and Mr. George R. McDermott, assistant chief engineer, were guests at a dinner given by the Iron and Steel Committee of the American Institute of Mining and Metallurgical Engineers, Friday evening, April 6, 1923, at the Engineers' Club in New York City, where they received the Sir Robert Hadfield award of \$1,000 for the best paper presented before any engineering society in the United States on "Fuel Conservation as Applied to the Iron and Steel Industry."

The funds for this award were established four years ago by Sir Robert Hadfield of England, to encourage research in the Iron and Steel Industry, and this is the first award which has been made.

Messrs. Kinney and McDermott were joint authors of a paper entitled "The Thermal Efficiency and Heat Balance of the Open Hearth Furnace," presented before the 1922 October meeting of the American Iron and Steel Institute in New York City.

Among those attending the dinner were Mr. J. V. W. Reynolds, vice president of the Institute; Dr. Mathews, President Crucible Steel Company of America; Dr. Campbell, Professor of Metallurgy, Columbia University; Dr. Saveur, Professor of Metallurgy, Harvard University; Dr. Waterhouse, Professor of Metallurgy, Massachusetts Institute of Technology; Dr. Hibbard, Dr. Tusada, Dr. Moldenke, Mr. Morris, Chief Metallurgist of the Bethlehem Steel Company; Mr. Stroughton, Mr. Sweetser, Mr. Carney and Mr. J. H. Gray of the United States Steel Corporation.

Messrs. Kinney and McDermott had the pleasure of visiting Mr. J. A. Farrell, president of the United States Steel Corporation, who desired to meet them, and during the interview Mr. Farrell expressed his appreciation of the paper and congratulated them upon the recognition they had received.

When the paper was presented before the Iron and Steel Institute in October, the authors had no knowledge that the Sir Robert Hadfield award or prize existed.

For the benefit of those desiring to read the paper on "The Thermal Efficiency and Heat Balance of the Open Hearth Furnace" as prepared by Messrs. Kinney and McDermott, we would say it appeared in part in the December, 1922, issue of "The Blast Furnace and Steel Plant" magazine.

On behalf of the officers and employees of South Works, we take pleasure in extending to our co-workers, Messrs. Kinney and McDermott, hearty congratulations for their meritorious paper, as we feel it is an exceedingly great honor these officials and South Works have had conferred on them by the American Institute of Mining and Metallurgical Engineers, a society composed of the most brilliant and highly trained minds in their line in the world, and their action surely indicates a recognition of high technical knowledge and ability on the part of Messrs. Kinney and McDermott.—South Works Review.

New Experiment Station at Rutgers

The Secretary of the Interior has designated Rutgers College, New Brunswick, N. J., as the location of a new mining experiment station of the Bureau of Mines, which will specialize in problems involved in the production and utilization of the non-metallic minerals. These minerals include bauxite, cement, clay,

feldspar, Fuller's earth, graphite, gypsum, lime, mica, phosphate rock, salt, sand and gravel, sand-lime brick, slate, stone, sulphur, mineral paints, garnet, asbestos, and talc. The value of these non-metallic minerals produced annually in the United States is in the neighborhood of a billion dollars.

The choice of Rutgers College was determined largely by the fact that its location is a central one with reference both to the production and consumption of non-metallic minerals. The adjacent State of Pennsylvania alone has one and seven-tenths times as great a production of non-metallic minerals as all the states south of the Potomac and Ohio rivers combined. The New England and North Atlantic States, which are readily served from New Brunswick with a minimum of travel, have a combined non-metallic output of approximately three and one-half times that of all the states south of the Potomac and Ohio rivers. Furthermore, about 75 per cent of the industries consuming the non-metallic minerals production center in the large industrial cities are within easy reach of Rutgers College.

U. S. Bureau of Standards Publications

These publications may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

SCIENTIFIC PAPERS

No. 452. Structure of Martensitic Carbon Steels and Changes in Microstructure Which Occur upon Tempering, by H. S. Rawdon and S. Epstein. 373-409 pages. 1922. 15 cents.

No. 453. Preparation and Properties of Pure Iron Alloys. Part I. Effects of Carbon and Manganese on the Mechanical Properties of Pure Iron, by Robert P. Neville and John R. Cain. 4H-443 pages. 1922. 10 cents.

No. 457. Gases in Metals. Part I. The Determination of Combined Nitrogen in Iron and Steel and the Change in Form of Nitrogen by Heat Treatment, by Louis Jordan and F. E. Swindells. 599-511 pages. 1922. 5 cents.

No. 463. Preparation and Properties of Pure Iron Alloys. Part II. Magnetic Properties of Iron-Carbon Alloys as Affected by Heat Treatment and Carbon Content, by W. L. Cheney. 609-635 pages. 1923. 15 cents.

No. 464. Preparation and Properties of Pure Iron Alloys. Part III. Effect of Manganese on the Structure of Alloys of the Iron-Carbon System, by H. S. Rawdon and Frederick Silvers, Jr. 637-653 pages. 1923. 10 cents.

TECHNOLOGIC PAPERS

No. 228. Lathe Breakdown Tests of Some Modern High-Speed Tool Steels, by H. J. French and Jerome Strauss. 183-225 pages. 1923. 15 cents.

Health Service at Lehigh

Believing that a good stock of health is a particularly important part of an engineer's equipment, President Charles Russ Richards of Lehigh University has announced that the university will institute a health service for its students in the near future. The health service will operate along the lines of the most approved preventive medicine.

A physician will give his time exclusively to directing the health service. Every student will be given a physical examination each year, and corrective measures will be undertaken where defects are disclosed. The director will treat minor ailments and insure proper treatment for all serious ones.

Lehigh students will be protected also by frequent examinations of sanitary conditions in all student eating places and also of employes who handle food. All places where students live will also be given a sanitary inspection.

A feature that may not prove so popular with students wishing to get excuses for absence from classes will be a compulsory examination by the director before such excuses are granted.

POWER PLANT SECTION

La Belle's Giant Uniflow

Superheat in the Steel Industry
By C. A. BRANDT

Steel Mill Installs Modern Softeners
By G. S. REYNOLDS

Dirty Steam No Longer Necessary
By LEWIS F. KUHMANN

Variable Speed Steam Turbine Stoker
Drive
By IVAN S. FORDE

Various Systems of Burning Pulverized
Coal
By C. F. HERINGTON

Graphic Method for Computing Heat
Balance
By F. A. SHORKEY

Stop-Check vs. Non-return Valves
By W. N. FLANAGAN

Super-heat in the Steel Industry

Recent Recognition of the Great Advantages Obtainable from
Higher Temperature Steam—Old Inefficient Power
Plants May Derive the Most Benefits

By C. A. BRANDT*

OF the many apparatuses that have been invented and placed in use for the purpose of saving fuel, there is none that can compare with the superheater in the production of higher economies of the generating units for the small amount of capital invested and its low maintenance cost. This fact has been so thoroughly demonstrated that no modern steam plant is now built without its use. While superheaters have been known for many years, it is only within the last 10 years that a recognition of its great advantages has become general, particularly the use of high degrees of superheat. For this reason, there are a great many large and small steam plants now operating without superheated steam.

Generally, these are the plants that are quite inefficient and can be benefited most by the application of super-

with superheaters. There are statistics available giving the amount of fuel used in these various steps of steel production, and the amount is very great indeed. A 10 to 25 per cent saving in this fuel by the use of superheated steam would help considerably in reducing the cost of the production of steel.

Good work has been done in the design of the large central plants to obtain fuel economy, but these few plants do not consume nearly as much fuel as the total of all the small steam plants that are necessary in steel production. It is the ore boats, steam shovels, towboats, locomotives, dock machinery and other installations of similar nature that can be improved and benefited most by the application of superheaters. The following will be a brief summary of what has been accomplished in the application of superheaters and consequent improvement in the economies of such plants:

Advantages Gained by the Use of Superheated Steam.

These are well known, but will be briefly summarized as follows:

1. A reduction in the steam consumption of any steam engine or turbine of from 15 to 35 per cent, as compared with the use of saturated steam, depending upon the degree of superheat used.
2. A reduction in the size and cost of the necessary boiler plant in the same ratio as the decrease in the steam consumption of the prime mover, or an equivalent increase in the capacity of the boiler in existing plants. This saving pays for the cost of the superheater many times.
3. A considerable reduction in the fuel consumption, ranging from 10 per cent to 25 per cent, depending on the degree of superheat and type of engine.
4. An improved condition in the transmission of steam in long pipe lines, reducing condensation losses and pressure drop.
5. A necessity in steam turbine operation for protection of turbine from damage, due to water slugs from the boiler, and also reduction in the bucket wear, due to water.
6. A saving in the cost of water used for steam purposes.

Adaptation of Superheaters to Various Types of Boilers.

The question of adapting a superheater to the many conditions found in practice has been difficult, but the last few years has seen most of these problems successfully solved, and the adoption of same in many new fields is necessary.

Space does not permit a detailed description of the superheaters for all of the plants mentioned before and only the latest developments will be touched upon.

Steam Shovels.

A very successful application is one to the immense steam shovels used for digging ore. Here is a steam

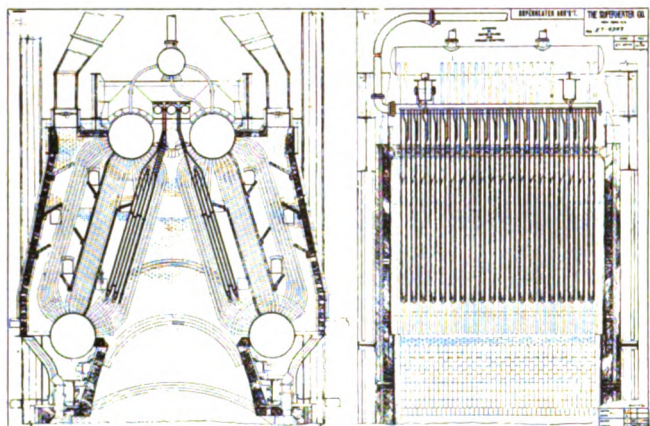


FIG. 1—Superheaters in the 2647-hp. boilers of Ford Motor Company. (Inclined type.)

heaters. It has been argued that inefficient plants should be scrapped and replaced entirely, but the tremendous increase in cost of new construction and the great demand for capital for additions and reconstructions due to the war, make many replacements impossible.

This is particularly true when old power plants can be brought up to a high state of efficiency, for a small expenditure of capital, by the application of modern appliances, of which the superheater is of the greatest importance, and the entire replacement of such plant would be an unjustified destruction of capital.

The steel plant manager is particularly interested in the economical consumption of steam, as large quantities of fuel are used in every step of steel production, and is a big item in its manufacturing cost. The giant steam shovels and ore-loading machines handling the ore and coal at the mines and docks, the large boats and locomotives transporting the ore to the mills, together with the towboats on the rivers and the immense steam generating plants used in the fabrication of pig iron and steel, all use large quantities of fuel and same can and should be fitted

*Chief Engineer, the Superheater Company, New York City, N. Y.

plant that is usually operated far away from a convenient supply of coal and water, bringing the delivered cost up very high.

The engines of a steam shovel operate, by necessity, with a long cut off, which results in a great amount of cylinder condensation.

Furthermore, due to the restriction in space and weight of the shovels, steam is generated under conditions that are unfavorable to attainment of good boiler efficiency.

Superheating such equipment to 200 degrees will bring the efficiency up to that of the average condensing engine plant.

Another important feature is the fact that the harder the superheated shovel is driven, the more economical it becomes, due to the increased superheat at higher ratings.

With the saturated shovel, this is reversed, as the harder such a shovel is driven, the more moisture and water are carried over into the cylinders, with a heavy loss of economy, capacity and speed.

A carefully conducted test on a Marion No. 300 steam shovel, equipped with an Elesco Firetube Superheater, manufactured by the Superheater Company, showed a saving in fuel consumption of 33 1/3 per cent, as compared with saturated steam operation. This shovel was used in heavy stripping and ore digging.

The installation of the same make of superheater in a No. 225 Bucyrus steam shovel, also used in ore digging, showed a saving of 30 per cent in fuel and 35 per cent in water after the shovel was equipped with a superheater.

These are typical of results obtained from other similar installations.

River Towboats and Steamboats.

Another type of engine that is particularly inefficient when operated with wet steam is the long stroke, slow speed engine used in river towboats and ferries. In these the cylinder condensation, with saturated steam, runs as high as 40 per cent, which can be entirely eliminated by the use of high degree superheat. A test of Elesco Superheaters, giving 200 degrees of superheat, applied to the car ferry "Huntsville," operated on the Tennessee River, showed a most remarkable improvement. The average daily performance of this boat after superheating showed a saving of more than 40 per cent in fuel, in addition to an increase in speed. This boat is 159 ft. long, 26 ft. beam, equipped with three flue boilers 38 in. diameter and 25 ft. 1 in. long. The 17-ft. diameter paddle wheels are driven by two 15x72-in. non-condensing engines. The reduction in the coal consumption permits a smaller coal bunker, reducing the draft of the boat, or making possible an increased cargo capacity.

The excellent performance of these superheater installations promises a very rapid adoption of the use of superheaters on river boats, towboats, ferries and dredges on the rivers.

Superheaters on Locomotives.

The use of superheaters on road locomotives is so general that little new can be said of this, except that there are now some 40,000 locomotives in this country and 25,000 in the other parts of the world, equipped with superheaters giving 200 to 250 degrees superheat. The extensive use of superheaters on switching locomotives should be noticed. This is of particular interest to the steel industry, where a great many switching locomotives are used in the mills, and as the size of these locomotives has increased very much in the last few years, the fuel saving is of considerable importance.

A test conducted on the New York Central some time ago showed a saving of 25 per cent in water and 23 per cent in coal, as compared with a saturated steam locomotive similarly tested.

A test on a heavy oil-fired switching engine on the Atchison, Topeka & Santa Fe Railroad showed a saving of 36.4 per cent in water and 37.5 per cent in fuel per I.H.P. hour. A coal-fired switching locomotive showed a saving 34.5 per cent in water and 25.7 per cent in fuel.

The superheaters on our locomotives produce a superheat of 250 deg. F.; many give 300 deg. with a total steam temperature of from 650 to 700 deg. F. These steam temperatures exceed by 50 to 100 deg. those used in the most modern central turbine stations in this country, and

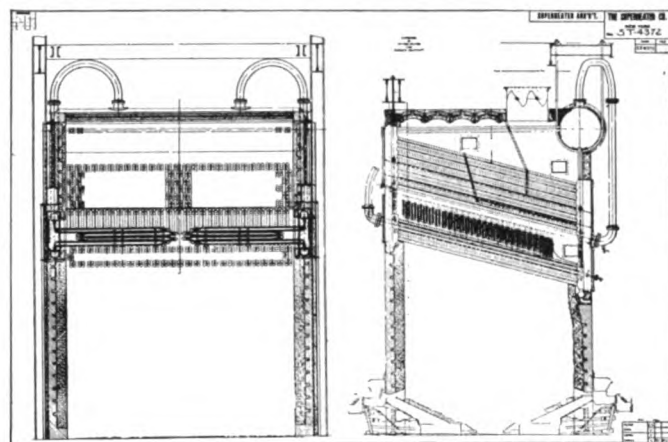


FIG. 2—Superheaters in the 1890-hp. boilers of Hell Gate Station, United Electric Light and Power Co. (Horizontal type.)

this development is an eloquent testimony of the progressiveness, determination and skill of the American railway officers.

The successful solution of the many problems of lubrication, maintenance and operation of engines, with these high steam temperatures unheard of a few years ago, is one of the most brilliant chapters in the annals of American railroad history.

The railroad that has been so closely identified with the growth of our steel industry, or the Pennsylvania, has in its many tests given an invaluable contribution to the art. It can truthfully be said that in the rapid application of superheaters the railway officers have truly revitalized the steam railroads of this country.

Ore Carriers on the Great Lakes.

The great increase in fuel cost has given the application of high degree superheaters on board ships a great stimulus. During the last 10 years high degree superheaters have been applied to some 2,200 ocean-going ships, which include the latest modern turbine-driven, as well as engine-driven, vessels. The most recent examples of this are the new Cunard liners in the "Scythia" class. These boats are equipped with geared turbines of 13,500 shp. and operated with 200 degrees of superheat, showing remarkably high economy.

Another most interesting installation is that of the steamship "Pacific," equipped with Ljungstrom turbine, using 300 degrees of superheat, where an efficiency of 3/4 lb. of oil per shaft hp. was obtained. This is considered the most efficient performance of any ship in existence.

An example where high degree superheats are used with large reciprocating engines is that in the new giant

White Star liner "Homeric." This ship is equipped with two triple expansion, four-cylinder vertical engines, with a total horsepower of 34,500.

All of these ships are equipped with the Elesco type Firetube superheater, giving a superheat of 200 degrees, or more, and a most satisfactory fuel and operating performance is obtained.

The new large freighters in the "Archer" class of the U. S. Shipping Board, equipped with turbo-electric drive, are equipped with superheaters giving 225 degrees.

The above facts will no doubt be of great interest to the steel industry, due to the many large ore-carrying boats operating on the Great Lakes, none of which is equipped with superheated steam. There are today in operation on the Great Lakes about 500 ore-carrying ships of about 2,000 shaft hp. each, and a reduction of from 15 to 20 per cent in the fuel consumption of these boats would mean a considerable saving in the cost of transporting ore on the Great Lakes. The successful and rapid application of high superheat to ocean-going vessels will no doubt soon follow on our Great Lakes.

Superheaters in Large Stationary Power Plants.

Superheaters have been used in stationary plants for many years, but it is only during recent years that superheat over 100 degrees has been attempted. Older types of superheater application are well known and the following will only cover the development of the latest and most advanced applications to large boilers.

The most interesting examples of such applications are those in the largest boilers in the world at the River Rouge blast furnace plant of the Ford Motor Company and in the 300,000-kw. power plant of the United Electric Light & Power Company at Hell Gate, N. Y. The design of these superheaters represents a distinct departure from old practice, and the excellent performance has proved the correctness of the principle of design.

In the older types of superheater equipment hitherto used, very little consideration was given to the possibility of so designing the superheater as to give as nearly

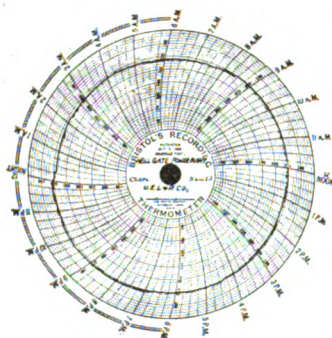


FIG. 3—Nearly constant steam temperature shown by chart taken from Ford boilers. (Fig. 1.)

uniform steam temperatures as possible under different operating conditions and ratings of the boilers, and the influence of gas temperatures, gas and steam velocity, as well as radiant heat upon the superheater was little understood. The necessity for correctly proportioning the steam area and superheating surface of each individual superheater unit was usually neglected, with the result that unsatisfactory superheater performance was obtained.

With superheaters located so as to place a large percentage of the boiler heating surface between the furnace and the superheater, the superheater receives heat only by convection from the hot gases sweeping over its surface.

The available heat in the gases, varying considerably with furnace conditions, boiler rating and fuel, causes the superheat to fluctuate considerably under the different conditions, usually producing a rapid rise in superheat as rating increases. Where the superheater is located directly in the furnace, it receives only radiant heat and as the heat emanating from a radiant fuel bed varies considerably, depending upon the condition of the fire, the excess air and the furnace temperature, great variation in the superheat may be expected.

Furthermore, the laws of physics tell us that the amount of heat absorbed by a surface exposed to radiant

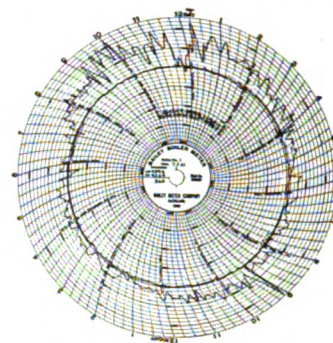


FIG. 4—Chart taken from actual performance of boilers at Hell Gate Station. (Shown in Fig. 2.)

heat only, varies as the fourth power of the temperature difference between that of the hot body and the absorbing surface. A variation of a few hundred degrees, therefore, in the furnace temperature, will affect the amount of superheat a great deal. It should also be borne in mind that the amount of radiant heat emanating from the hot fuel bed in the furnace does not increase in the same proportion as the boiler rating and as the heating surface of the superheater is constant, the amount of superheat is bound to drop in proportion to the increased boiler rating, and which drop is augmented due to the increased moisture in the steam at the high boiler ratings.

In the first mentioned type of superheater, the amount of superheat increases with the rating, while with the strictly radiant type of superheater it decreases. The first case is not injurious, as it is desirable to obtain the higher temperatures at the higher ratings if it does not exceed the maximum permissible.

In the superheaters installed in the plants above mentioned, both of the conditions mentioned above have been eliminated and the superheaters have been so located in the boiler heating surface as to receive heat both from radiation and convection from the gases. The other important development in superheater design previously mentioned and incorporated in the installations referred to, is the desirability of so proportioning each individual superheater unit as to obtain the desired superheat from each individual superheater unit. When it was desired to obtain high superheat with superheaters of older design, the increased superheater heating surface was obtained by adding additional units. This produced a proportional increase of the steam area, resulting in an undesirable reduction in the steam velocity, causing much trouble from various sources, such as wide fluctuation in the superheat, slugs of water carried through the superheater without being broken up and evaporated, and accumulation of scale forming matter and mud in the superheater units, deposited because of low steam velocity.

(Concluded on page 344)

Steel Mill Installs Modern Softeners

Careful Investigation Shows Necessity of Improving Power and Cooling Water Conditions, by the Introduction of Latest Water Softeners

By G. S. REYNOLDS*

THE West Penn Steel Company's mill at Brackenridge, Pa., has a boiler plant consisting of 10 units of Wickes Boilers rated at 350 hp. each, fired by Murphy furnaces and developing up to 5,000 hp. at peak loads and with frequent and continued output at the rate of 4,000 hp.

There are also three locomotives in use and two traveling cranes.

The water used by the plant for all power and mill purposes is pumped direct from the Allegheny river.

the standpoint of the boiler feed water has left much to be desired.

The company has been studying the problem of suitable means of relief ever since 1917, and after careful investigation the plans were matured and put into execution in the summer of 1922.

There are four open hearth furnaces which are being provided with water cooled devices, and will use 16,000 gallons per hour, and there is a use of water for rolls, etc., which by careful check was found to be 10,500 gal-

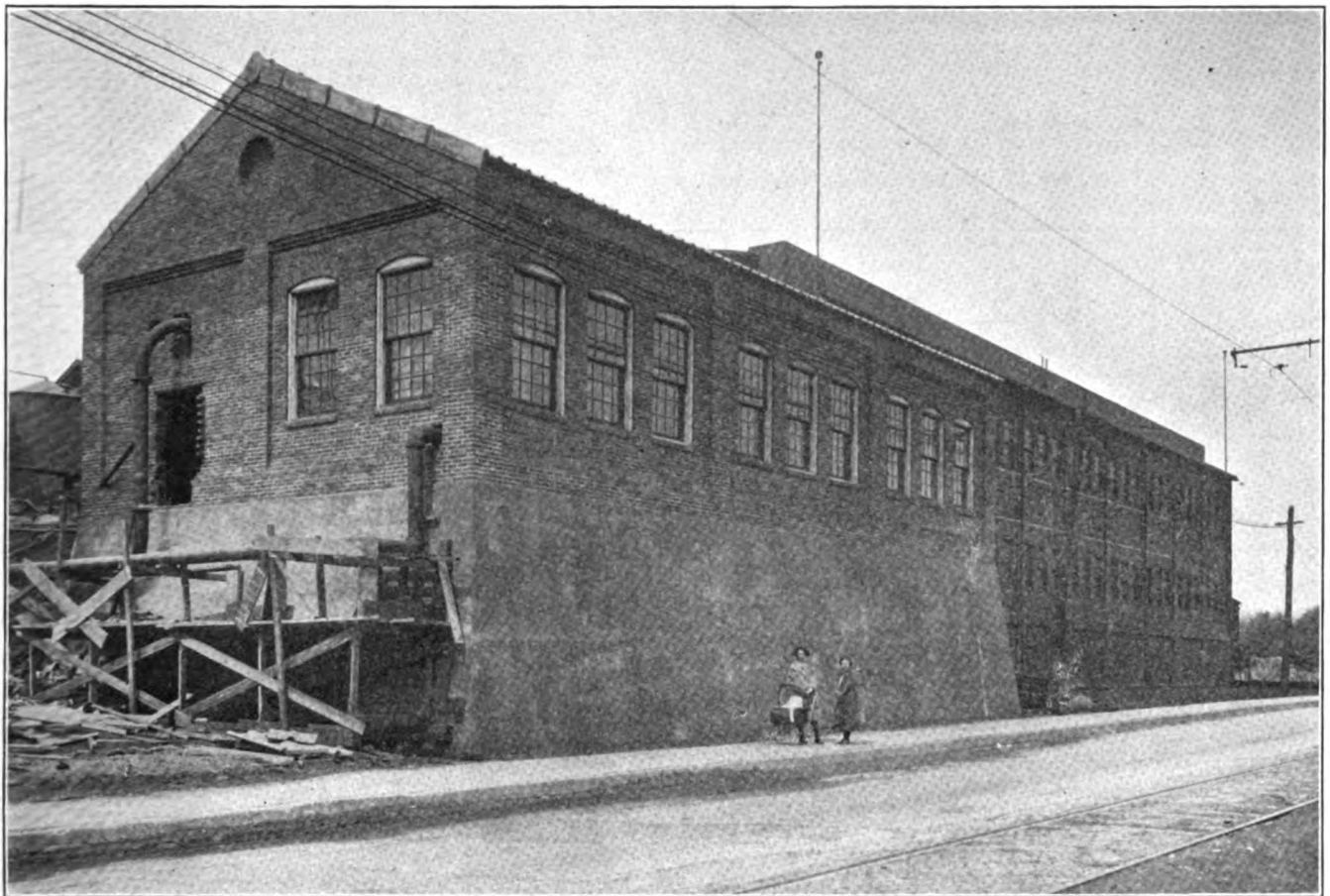


FIG. 1—Completed building housing purifying plant.

This supply has given considerable trouble on account of mud, iron and acid. The boilers have required frequent blowing down, twice to four times each 24 hours and at least 3 inches each time. Scale of a hard character has always been found when boilers are opened and varies from 1/16 inch to 1/8 inch. There has also been trouble from foaming and priming. Boiler compounds have been used, and altogether the situation of the plant from

lons per hour. Total water required for these purposes, say, 27,500 gallons per hour. In the opinion of the engineering staff, the problem was by no means confined to boiler feed water.

It has seemed that great advantage in the running of open hearth furnaces and mills would result if instead of using raw water more or less loaded with scale forming solids, there should be a complete filtration of the water used in these parts of the plant. Shut-downs would be lessened and the life of the expensive apparatus would be greatly increased.

*Master Mechanic, West Penn Steel Company, Brackenridge, Pa.

It became evident as the investigation proceeded that the ordinary treatment of the boiler water with lime and soda would not be a complete solution of the existing troubles.

There appears to be always a certain amount of scale forming material in water thus treated, and if there is any, then boilers must be cleaned. Investigation indicated that very often there was "overtreatment" in lime soda installations which made conditions worse instead of better, if not carefully guarded against.

The effort has been to find a plan which would insure clean boilers which would stay clean.

Of course, it was necessary that this result should be brought about in such a manner as not to involve complicated or delicate apparatus.

After careful inspection of other boiler plants and a thorough examination of all the claims of various manu-

having a capacity of 43,000 gallons.

In line with the other tanks stands the softened water reserve tank with a capacity of 30,000 gallons.

All these tanks are about 30 feet above ground level and are aligned at right angles to the frontage of the plant on the Allegheny river.

These storage tanks are shown in illustration, Fig. 4.

Adjoining the tanks on the north there has been constructed a concrete settling basin having a capacity of 160,000 gallons and being 31 feet by 61 feet by 12 feet 6 inches deep.

This basin is divided into two main parts, by concrete partition walls. On the inlet there is a mixing chamber running along one end of the main reservoir. This chamber is furnished with concrete staggered baffle plates. The rest of the settling basin is furnished with concrete baffles spaced suitably so as to give the proper

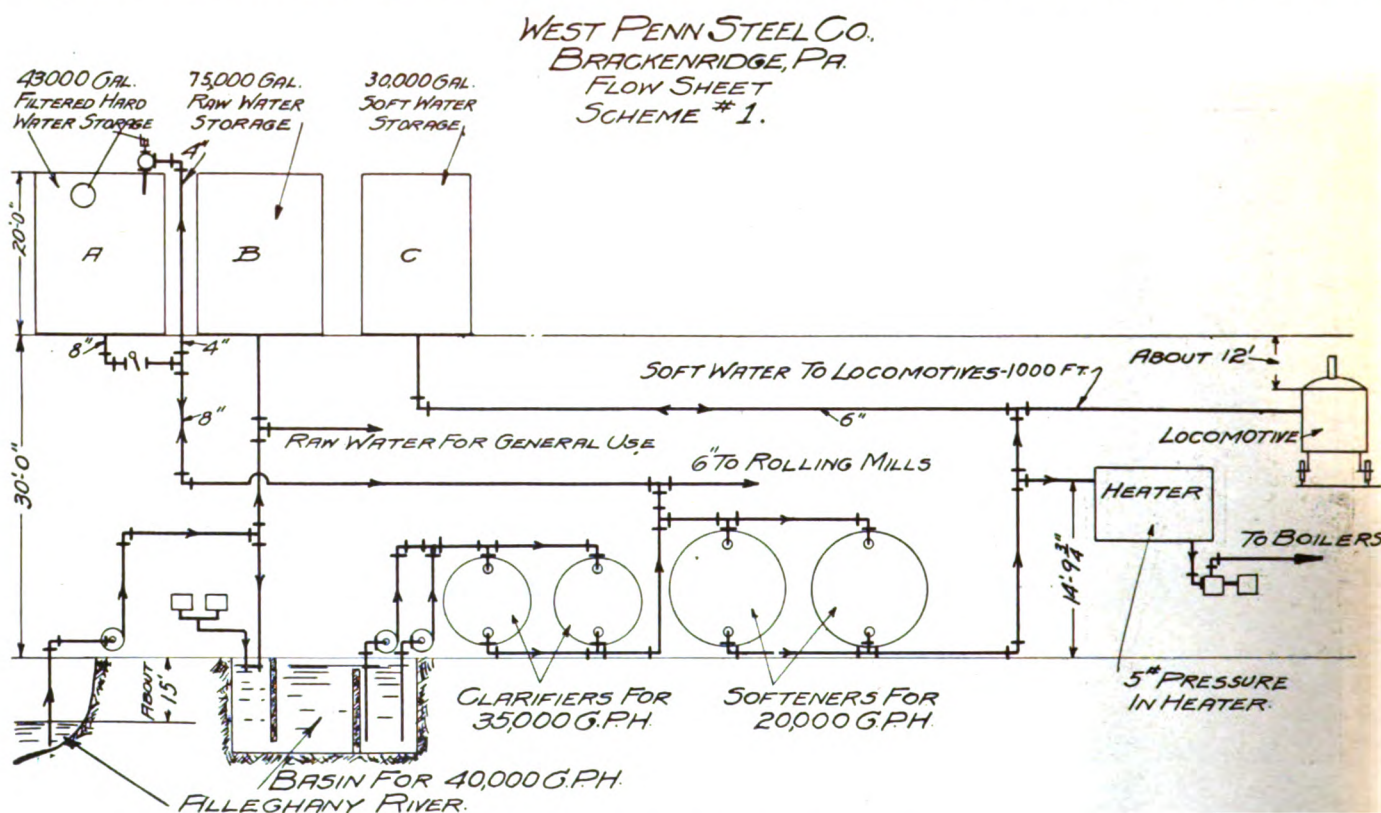


FIG. 2—Flow diagram of water-softer layout.

facturers, it was finally decided to install a system which should include Zeolite Water Softeners.

The installation at this writing is completed.

As this is the first plant of its kind in the steel industry in the Pittsburgh District it has been thought that a description of the plant might be of interest.

The requirements of the mill and open hearth plant when completely furnished with necessary water service would figure 720,000 gallons of filtered water per day of 24 hours; and there would be required 480,000 gallons of absolutely soft water for boilers per day of 24 hours.

To meet these requirements plant installation has been made as follows:

For emergency and other plant purposes, there is an elevated steel tank for raw water located near the filtering and softening plant, having a capacity of 75,000 gallons.

Alongside of this is a storage tank for filtered water

serpentine motion to the flow of water, and thus produce the maximum settling result in the space available.

The settling basin is roofed in by a reinforced concrete floor supported by suitable beams for carrying the weight of the filters and Zeolite Permutit Softeners, which are mounted upon the floor. The centrifugal Worthington pumps, motor driven, are located in a battery at the southwest corner of the building.

There is ample room on this operating floor for the storage of salt and other supplies needed in the operation of the plant and for the office and testing laboratory for the operative in charge.

The concrete settling basin thus forms the basement of a brick house. This has been designed so as to be in harmony with the office building and roofed with concrete tile. It forms a slightly building fronting on the street which passes along the river frontage of the plant.

The complete structure is shown in illustration, Fig. 1.

The concrete basin was lined for water-proofing purposes with "Gunitite" put on by a cement gun. So successful has this been that the first and only test necessary showed the tank entirely tight when filled.

Upon the operating floor are installed two 8 ft. by 16 ft. 3 in. horizontal clarifying filters mounted on brick supports and set in battery and connected by suitable piping and valves for operation and backwashing.

In line with the filters and receiving the filtered, neutral water with them, are two horizontal Permutit Zeolite Softeners, each 9 ft. in diameter and 11 ft. 4 in. long.

The battery of filters and softeners is shown in illustration, Fig. 3.

These Softeners are served by a wood salt dissolving tank of 600 gallons capacity, the salt solution from which passes to a salt solution tank also of wood 10 ft. diameter and 8 ft. high, and from this the solution is siphoned into the softeners when regeneration is required.

Suitably disposed and adjoining the raw water inlet to the settling basin are two steel solution tanks 8 ft. in diameter and 4 ft. high in which the alkali for neutralization and alum for coagulation are respectively dissolved.

These treating solutions are fed through gravity orifice basin to the raw water supply at appropriate points in the mixing chamber above described.

The cycle of operation is as follows:

Raw water is pumped from the river through a 14-in. pipe by a centrifugal pump, turbine driven, to the raw water storage tank above described. The raw water storage has a lead of pipe with suitable valves from it to the plant for general use. From this an 8-in. line is run to the mixing chamber of the settling basin.

The raw water is treated with alkali and alum in the mixing chamber and passes from it to the settling basin,



FIG. 3—Battery of Zeolite filters in foreground. Sand filters at back.

where it settles for four hours. The settled water is pumped to the clarifying filters and passes directly from these to the Permutit Softeners.

But there is a head of 8-in. pipe from the line between the clarifiers and the softeners to the filtered water storage tank which is provided with a suitable float valve to regulate the supply to the tank. And from this line between the clarifiers and the tank there is a lead of 6-in. pipe to the mill.

The water to be softened is piped from clarifiers into the Permutit Softeners where the hardness of the water is absolutely removed and reduced to zero by the action of the Zeolite bed.

Only one softener is operated at a time and the continuous operation of the plant is secured by having the softener capacity adjusted to a period of eight hours between regenerations. So one softener is working at any time, the other being regenerated with common salt. As

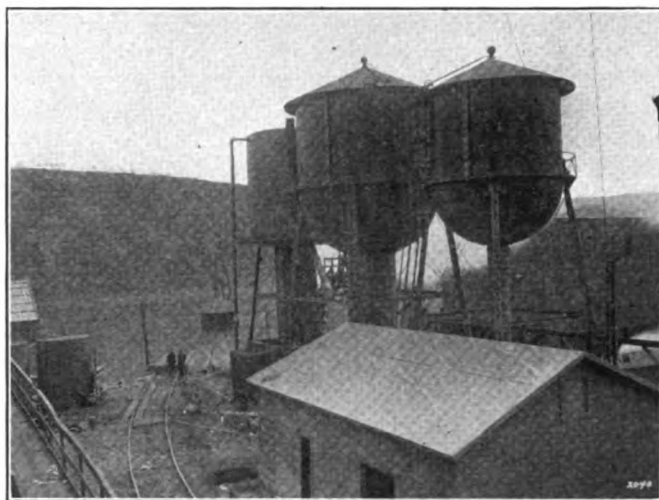


FIG. 4—Water tanks for plant storage.

soon as the operating period of eight hours is finished the softeners are simply switched, the work of but a few seconds.

The salt and solution tanks are always available for regeneration of a softener either in the customary cycle of operation or in emergency.

The pumping plant is in duplicate and every safeguard possible has been taken advantage of for continuous operation.

From the softener in service the zero water passes to the feed pumps and heaters and thence to the boilers.

There is a lead of 6-in. pipe about 1,000 ft. long from the water treating plant. This serves the locomotives and traveling cranes through hydrants suitably disposed in the yard. The accompanying diagram will illustrate the operation.

A future article describing the results obtained from the operation of this plant will be forthcoming when the study has been made complete and tabulated.

The Pittsfield Coal Gas Company has lately awarded contract to the U. G. I. Contracting Company of Philadelphia for the installation of additional carburetted water gas apparatus. The apparatus will be equipped with the U. G. I. automatic control. The contract also calls for the installation of complete blowing plant in duplicate, together with a blast main system which will connect with all of the water gas apparatus in the generator house. Also additional high duty condensing system and take-off mains. Over 2,000,000 cu. ft. daily manufacturing capacity will be added to the plant by the addition of this equipment.

The U. G. I. Contracting Company has received contract for the installation of an 8-foot cone top carburetted water gas apparatus to be installed at the plant of the Burlington, Iowa, Gas Light Company.

Dirty Steam No Longer Necessary

Impurities and Chemicals Ordinarily Carried Over with Steam into
Lines and Engines Can Be Stopped at Boiler Nozzle
—"Blow-Downs" Are Ineffective

By LEWIS F. KUHMAN

EVERY engineer who deals with the use or generation of steam has had some piece of automatic equipment fail to operate, and upon examination found that it has been clogged with "dirt," or "soda-ash," or some "white stuff" which has to be cleaned out only to clog up again. After this has occurred several times, with possibly serious results, the usual proceeding is to go to the water treating man and "bawl him out" for putting too much soda-ash into the water. He protests violently that if he treats any lighter he can't keep the boiler scale out of the tubes.

The next step is to call the company who sold the treating system and who quickly gets a man on the job, and he does everything that is possible with the treating system toward correcting the troubles experienced. He leaves; and about that time a turbine or engine emergency valve sticks with more or less serious results. Maybe this time the manager is appealed to, and he gets on the job with lots of fireworks—and no results as far as clean steam is concerned.

and joints; plugged traps; dirty condenser tubes; engine breakage and excessive wear. In other words, wet steam and dirty steam, which are the primary causes of these troubles, should not be blamed on boiler design. Nor is the treating system at fault. The fault lies solely and wholly in the "dry-pipe" not being a *dry* pipe.

If a little thought were only given as to where the chemicals ultimately went that are so freely added to those already in the raw feed water, it would be at once apparent that the treating system is not at fault; that is not primarily. The fault lies in allowing any of them, or the water carrying them in solution, to get out of the boiler drum into the steam system. The solution is the installation of an efficient dry pipe; not one that will give maybe 99½ per cent dry steam, for that is not enough, but one that will give 100 per cent dry steam. When that is done the troubles from impurities in the steam, clogged and cut turbine blades, plugged up superheaters, inoperative safety devices, etc., will be eliminated, and not before.

It is useless to fuss with the treating system to try to prevent deposits in the steam system as long as you have even one-half of 1 per cent moisture leaving the boiler drum with the steam. The amount of chemical that will carry will amaze you if you stop to figure it out. To illustrate this point look at Fig. 1. The details and method of calculation are shown on page 341.

Where feed water is treated with the usual lime and soda ash treatment the hard scale forming salt carried in the feed water of the form CaSO_4 combines with the soda ash (sodium carbonate) forming an insoluble carbonate which can be filtered out but which leaves sodium sulphate in solution. This sodium sulphate can be concentrated as high as 25,000 grains per gallon before reaching saturation point. From this it will be seen that the only way this sodium sulphate can be removed from the boiler is in liquid form, either by blowing down the boiler or in the water carried out from the boiler drum with the steam.

Under ordinary operating conditions the proportion of water removed by blowing down is comparatively insignificant compared with the small percentage, but large amount, of water leaving the steam drum entrained with the steam. For instance take the following case:

Assuming a single steam drum boiler having a drum 54 in. in diameter and 18 ft. long, developing 2500 bhp. Further assuming 98 per cent dry steam leaving the boiler drum and that the boiler is blown down twice in 24 hours, each blow-down lowering the water level 4 in. in the drum. Under these conditions, of the total amount of water (as carrying sulphate in solution) 91¾ per cent leaves the steam drum in the steam, as compared to only 8¼ per cent leaving the blow-off. Eleven times as much water—and dirt—goes out with the steam as through the blow-off.

Remembering that every 100 lbs. of soda ash makes as a by-product 134 lbs. sodium sulphate, it will be seen, therefore, that for every 100 lbs. of soda ash added to

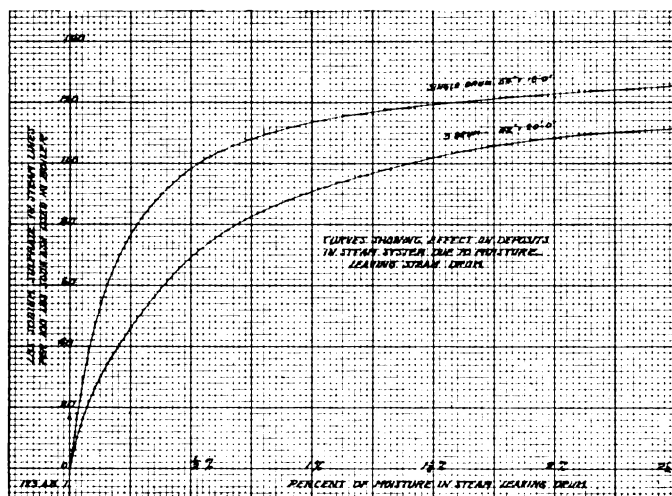


FIG. 1—Shows the comparative totals of solids carried over into the steam system with varying percentages of moisture; the upper curve represents the operation of a single-drum type boiler; the lower curve is taken from a typical Stirling type boiler.

And so it goes, with the poor feed water treating operator getting it from both sides—from the engineer for "over treating," and from the boiler foreman for scale in the tubes. And all because of the inefficiency of one little piece of pipe, full of holes, whose design has not been changed in 40 years, and whose existence in most plants has been entirely forgotten, the so-called "dry-pipe."

It is the failure of that "dry-pipe" to function according to its name that causes your troubles of clogged valves, eroded and clogged turbine blades and nozzles, jammed and inoperative back pressure valves, safety governors and service valves; plugged and burned superheater tubes; low and erratic superheat; leaking gaskets

the feed water in the above case 123 lbs. of sodium sulphate will leave the steam drum and enter the steam system. The details of this calculation are shown in Fig. 3. It will be noted that this does not include the salts and dirt carried over intermittently in case the boiler foams, it simply covers the amount of salts to be expected in the steam system as a result of 98 per cent quality of steam leaving the steam drum. The only way to entirely eliminate this condition is to prevent every trace of concentrated boiler water from leaving the steam drum, with the steam.

Chart No. 1 shows weight of sodium sulphate leaving the boiler and entering the steam system, expressed as lbs. of sulphate per 100 lbs. sodium carbonate added in the treating system. This is shown for various percentages of moisture in the steam leaving the drum. These two curves, one for a single drum boiler and the other for a three drum boiler, both operating at 2500 developed bhp., were calculated in the same manner as shown in Fig. 3. They indicate how essential it is that every trace of moisture be removed. For instance:

In a 3-drum boiler delivering 98 per cent dry steam, 108 lbs. of sodium sulphate will enter the steam system for every 100 lbs. of soda ash used. If changes in boiler design or operation are made, and this 98 per cent dry steam is increased even to 99½ per cent, there will still enter the steam system 69 lbs. of sulphate per 100 lbs. of soda ash. That is while the moisture content is reduced 75 per cent, the dirt and salts leaving the boiler with the steam is reduced only 36 per cent.

To show how inadequate it is to attempt to cure the condition by increasing the number of blow-downs, Fig. 2 has been prepared. With two blow-downs per 24 hours, in a single drum boiler, 123 lbs. of calcium sulphate enters the steam system per 100 lbs. of soda ash used. Increasing to eight blow-downs, which means blowing down every three hours, only reduces the amount to be expected in the steam line from 123 to 99 lbs. Or, while the blow-down has been increased 400 per cent, the dirt and salts leaving the boiler with the steam will be reduced only 19 per cent.

The answer to the problem is clearly indicated in Fig. 1, 100 per cent dry steam. With 100 per cent dry steam none of the salts pass over. That this is the case is clearly proven by the experience of plants which have replaced their old fashioned dry pipe. Just to cite an example from among many:

The Springfield Light, Heat & Power Company, Springfield, Ohio, last year replaced their old, so-called "dry pipe" with a type which insured absolutely 100 per cent dry steam. Before this they had been having very serious trouble with impurities in the steam. Although there was an average of only 1½ per cent moisture in the steam going to the superheaters, the superheaters were constantly clogging with dirt and salts. One of the main turbines, due to cut blades, had to be rebladed after only 1100 hours of operation.

Since the installation of a type of dry pipe which prevents any moisture being carried over with the steam, the superheat has increased about 20 degrees, the superheaters remain clean, and no evidence of cutting has been observed in the turbines. Recently an analysis of the steam was made by condensing samples taken from the saturated header, and having these samples analyzed by chemists. The report was that this water had less solids in it than the distilled water used in the chemical laboratory.

Here is a plant where their troubles due to dirty steam were probably as severe as at any plant in this country. And the entire trouble was obviated by merely replacing their old type inefficient "dry-pipes" with up-to-date ones that insured 100 per cent dry steam at all times.

In this day and age it is axiomatic that what is inefficient will ultimately be done away with, or replaced by something that is efficient. And in no phase of our industrial life is this axiom more apparent than in engineering. The day of the "dry-pipe" which gives "commercially dry steam" is over, and only some type which really produces results will be accepted in the future.

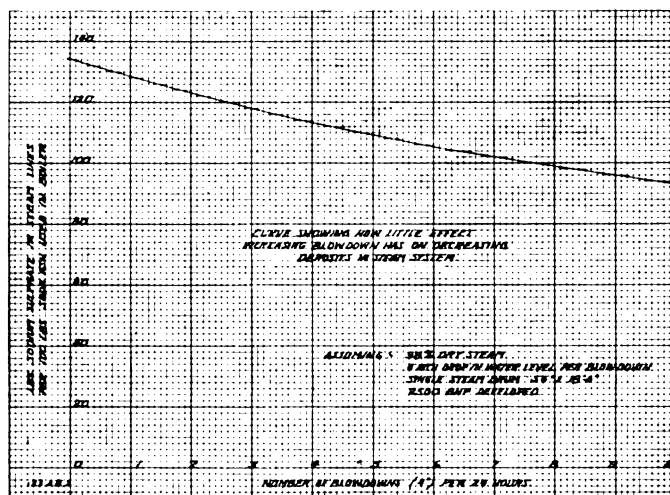


FIG. 2—Shows how slight effect the usual "blow-down" practice has upon boiler concentration, and upon the actual solids carried over into the steam system.

If you want to get rid of troubles due to salts and dirt in the steam don't jump the feed water treatment man, but look to see what provision you have in the boiler to get 100 per cent dry steam. Don't make futile efforts to increase the blow-down or to reduce the amount of moisture in the steam a little by changes in operation. The curves shown here prove how absolutely ineffective such makeshift methods are. Investigate and see if you do not still have one of the little old so-called "dry pipes" in your boiler. That is where you will find the source of your troubles. Correct that obsolete design by installing an efficient one and your dirty steam troubles will be over.

Calculations Showing Method of Determining Amount of Sodium Sulphate Thrown into Steam System

Assuming:

- 54" dia. x 18' 0" long steam drum.
- 2500 bhp. developed.
- 98 per cent dry steam leaving boiler drum.
- 4" lowering water level per blow-down.
- 2 blow-downs per 24 hours.

Calculations:

$$\begin{aligned} \text{CaSO}_4 + \text{Na}_2\text{CO}_3 &= \text{CaCO}_3 + \text{Na}_2\text{SO}_4 \\ (\text{Hard Scale}) + (\text{Soda Ash}) &= (\text{Precipitate}) + (\text{Soluble Salt}) \\ (\text{In water}) + (100 \text{ lbs}) &= (\text{Filtered out}) + (134 \text{ lbs. in solution}) \\ 4" \times 54" \times 18' \times 60 \text{ lbs} \times 2 &= 135 \text{ lbs. water per hr.} \\ 12 \times 12 \times 24 & \text{blown off.} \end{aligned}$$

98 per cent dry steam means 1500 lbs. water leaving steam drum per hr.

(Concluded on page 347)

Variable Speed Steam Turbine Stoker Drive

While the Generating Units Will Come in for Their Share of This
Economic Discussion, the Most Vital Spot Will Be the
Boiler Room, Its Auxiliaries and Steam Piping

By IVAN S. FORDE*

IN the operation of a power plant, the basic responsibility is to deliver steam to the main generating units. In other words, before you can have auxiliary steam power or electric power, you must first generate steam in the boilers safely, economically and reliably. And it follows that within safe limits the boiler room must be independent of the main generating units or other electric power in its ability to quickly bring up steam to the proper pressure without depending for aid in doing this from the main units.

A power house may be likened to a factory, and the variables entering into the operation of the factory must be secondary to the factory itself. *Therefore, the guaranteed production of steam is the first important item, with economy secondary; particularly when you consider that at least 75 per cent of the heat in the exhaust steam is recoverable from steam driven auxiliaries when you put through a feed water heater.*

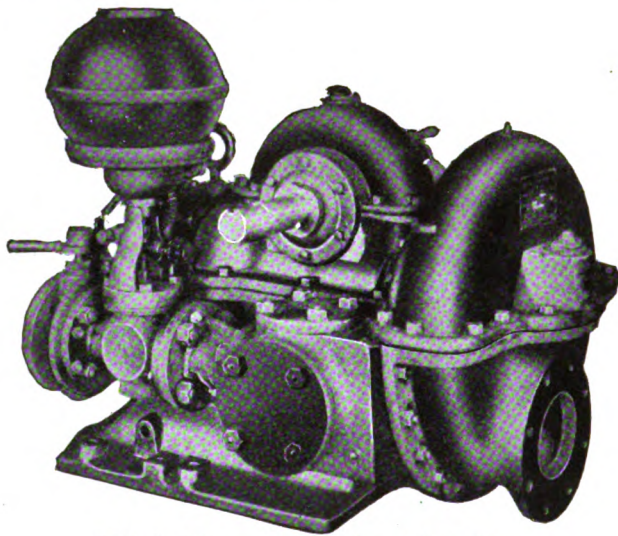


FIG. 1—Steam turbine for stoker drive.

With this thought indelibly impressed upon the mind, one will see that it does not always follow that driving boiler feed pumps, stoker fans or the stokers themselves with electric power is a wise economy, or a wholesome contribution to reliable operation. The pendulum will ever swing, and it must always come back! I refer particularly to the matter of bleeding live steam for feed water heating from the intermediate stages of the main generating units, in order to dispense with steam turbine driven auxiliaries; and I venture to remark in passing that if this be done to excess, with false economies set up that affect reliability or independence of the boiler room, the pendulum will again swing back to a greater use of better built small turbines.

The ideal way—and also the practical way—is to provide reliable steam driven auxiliaries up to the point of providing an economic heat balance, and after reaching

that point to provide duplicate steam-electric auxiliaries.

And since even in the use of steam driven auxiliaries reliable economies can be made, it seems pertinent to coin the expression "economy of reliability," for the thought back of this expression is beginning to rear its head above that of the bald statement of "pounds steam per brake horsepower" of an individual unit.

This thought is far more noticeable with the advent of high steam pressures and temperatures, and it has given both the manufacturer and operator some problems hitherto of secondary importance in the operation of a power plant.

To you who buy and operate various forms of mechanical stokers, both underfeed and chain grate type, I ask how much consideration have you given to the driving power for these stokers? You readily appreciate what a vital element the stoker is in the operation of your plant, both from economy and reliability standpoints; and you are becoming expert in both their purchase and operation, because you appreciate they are the foundation of your boiler room, rather than the boilers.

You know that you require variable speed in the driving of your stokers because you have a varied curve of steam demand, and the capacity and speed of your mechanical stokers will follow up and down as your steam demand varies. *And depending upon how promptly and reliably these stoker speeds are changed, will depend the economy to be obtained with various forms of mechanical stokers.*

Therefore, I again ask, "What is more important in the face of greater demands upon the stokers and boilers in the form of greater capacities and pressures than the auxiliary power for driving the stokers?"

Until recently two forms of drives were in use in obtaining this speed variation; one the steam engine, the other divided into two branches, direct and alternating current electric power. Waiving aside, for the moment, the question of complicating the simplicity of your boiler room with electric current, particularly alternating current with its intricate control, and on the theory that the boiler room should be independent of the main generating room, it naturally follows that stokers themselves should be the last ones to ever consider driving by electric power.

So far as steam engines are concerned, it seems self evident that the small, simple steam engine has no place in the modern plant. Were it a success it would still be used for the driving of pumps, fans and generators in central station work. Those that were installed years ago have given way to the small turbine, and now stand idle as monuments to perpetual progress, and the survival of the fittest. The mere fact that all the auxiliaries in the modern power house are now driven by steam turbines rather than engines bespeaks their superiority wherever pressures exceed 150 pounds. In brief, the steam turbine lends itself more readily to high temperatures than the engine. This is because of the absence of internal lubrication in the turbine, and the fact that the

*London Steam Turbine Company, Troy, N. Y.

turbine can be equipped with suitable materials for extremely high pressure steam and superheat, whereas it is difficult for the steam engine to solve the *high* temperature problem.

The customary way of attempting to obtain variable speed on the stoker drive in the case of steam engine operation was by throttling the main engine throttle valve by hand. This method is unsafe since it removes the unit

The Unit.

The ideal stoker drive should be capable of:

- 1—Exerting a heavy torque at slow speed.
- 2—Increasing this torque automatically when there is a tendency of choking.
- 3—Varying its speed throughout the range of stoker operation without danger of stalling.

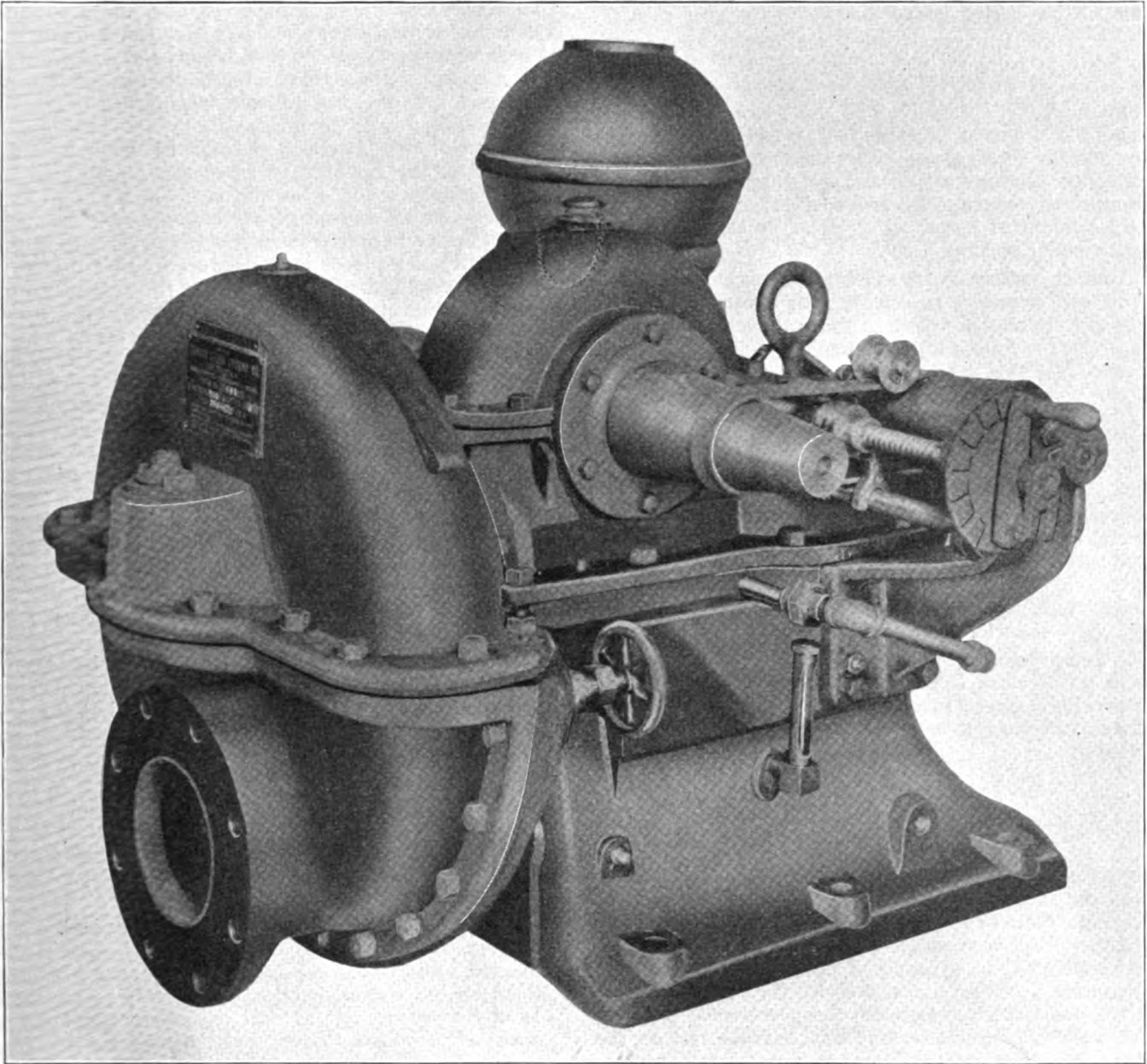


FIG. 2—Stoker drive turbine with cone pulley and belt for varying speed.

from under governor control. *Therefore, any form of steam unit driving mechanical stokers in these days of high temperatures must at all times be under the control of the governor regardless of load or speed.*

It was with the thought of "economy of reliability" that prompted the design of a variable speed steam turbine unit, designed expressly for the operation of mechanical stokers of the underfeed type, and also a somewhat smaller unit, both as to horsepower and speed, for the driving of slower speed chain grate stokers.

It is needless to say that these essentials so necessary to a stoker drive's success are incorporated in the design of this unit.

The first is accomplished by using a worm and gear reduction which has proven most satisfactory for this work.

The second is by the use of a throttling governor, which is partly throttled at all operating speeds. As the resistance of the stoker increases, due to obstruction or any other cause, the governor immediately opens up, thus increasing the nozzle pressure. After the obstruction is

removed, the speed increases and the governor checks and holds it at the desired value.

The third element necessary for successful operation is by means of a variable speed drive of the governor. The governor of this turbine is driven by a friction drive, arranged for operation either automatically or by hand, the speed range being between the maximum and minimum speeds required in stoker work, usually 100 to 400 rpm.

In general, this unit consists of a gear case with a steam turbine casing bolted directly to the gear case.

The simple features of this drive are the use of only two bearings for both the turbine rotor and the worm. The worm is supported at either end by a substantial babbitt lined sleeve bearing, and this worm shaft is also extended a sufficient distance for carrying the turbine rotor and the steam gland. This therefore eliminates the usual four bearing turbine and gear unit, and has the advantage of reducing the first cost and upkeep, as well as the amount of space, which is of great value in the modern boiler room.

Another feature is the absence of packing to retain the oil level necessary to submerge the worm. The slow speed gear rotates in a bath of oil, water cooled, and the unit is also provided with a submerged oil pump for lubricating all bearings.

This drive also contains the other well known features incorporated in correctly designed steam turbines, such as labyrinth metallic steam gland; central support for the turbine casing, assuring its successful operation on extremely high steam pressure and temperatures; split turbine casing and gear case to afford easy inspection of all internal parts, with steam and exhaust piping on the lower half of the turbine casing to permit inspection without breaking steam joints; and, finally, the justly famous London duplicate weight emergency governor with butterfly valve is included with each unit.

In addition to the steam jets used for auxiliary operation, a set of extra large, hand controlled auxiliary nozzles provide a considerable increase in power for starting up new, stiff stokers, or for use in extremely low steam pressures.

Super-Heat in Steel Industry

(Continued from page 336)

The great improvement in the superheaters referred to lies in the fact that the superheater heating surface for each individual element is correctly proportioned for the amount of superheat specified and to the steam area of each element. This principle of design makes it possible to maintain a correct steam velocity through the superheaters, and will automatically keep the elements free from scale forming matter and mud carried over by the steam. This is a radical departure from previous practice in stationary superheater designs, but the correctness of this principle is amply demonstrated by the fact that over 40,000 locomotives now equipped with such superheaters and so designed have given absolutely no trouble from scale formation inside of the units, in spite of the fact that locomotives usually receive very impure water.

Attached illustration, Fig. 1, shows the employment of this design in the large boilers at the Ford Motor Company, and Fig. 2 shows the design in the Hell Gate boilers. A noteworthy feature in both of these designs is the absence of any joints in the superheater units inside of the boiler setting. This gives assurance that no leak can exist inside of the boiler from the superheater.

Stop Check Valve vs. Triple Duty Non-Return

By W. N. FLANAGAN*

IN years past, when cast iron fittings and flanges were used for steam piping, cases of failure of the piping occurred once in awhile, perhaps due to the growth of the cast iron from the effect of temperature or from an occasional water hammer. Under these conditions demand occurred for a valve to protect human life in these emergencies. This valve was the Triple Duty Non-return. Since that time, modern practice has developed into the use of steel piping with vanstoned joints, rolled steel flanges and cast steel fittings. By the use of this material, the hazard taken by the engineer in the installation of steam piping, has been considerably reduced, as the steel does not grow appreciably under the effect of temperature. In case of slight water hammer, even if a break occurs, the steel does not go to pieces in the same way that the old cast iron material did. For this reason, the necessity for the triple duty valve for ordinary temperatures up to a maximum of 600 deg. has been done away with and that a stop-check valve is a lower priced and a better safety proposition in case of failure of tubes in the boiler. The steel plants having steam lines running from boiler plants to various processes still have some reason for protection against steam line breakage by collision of cranes or other moving objects, or due to cast iron fittings, etc., but these hazards do not occur in the modern boiler room and the proper place for protecting against such accidents would be to insert a triple duty non-return valve or automatic trip engine stop at the point in the boiler house where the steam line leaves it. Motor operated valves are also finding favor for this service.

Most of the steel plant boiler houses have several of these outlets and therefore, if an accident occurs to one of them, the steam supply is stopped at this outlet only, the others continuing to function and the boiler plant is not completely shut down as would be the case if the triple acting valves had been in service at each boiler outlet.

Most boiler plants would get into very serious difficulties if the load should be suddenly reduced and the steam to the boiler feed pumps cut off by the triple acting valves closing.

The writer has not heard of a header break occurring where same is constructed entirely of steel and is located under the roof of a boiler house and where there are no cranes or other heavy moving equipment. It is the opinion of several engineers consulted that such an accident under these conditions has never occurred. It, therefore, appears as though the value of a triple duty valve for such service is very doubtful except in special cases. The most important feature in the stop-check valve is to have such a valve that will not stick in case of a failure of the boiler tube. The design of such valve should be so that this would be least possible. The valve should be so designed that the moving parts of the check are entirely separated from the body, therefore, not subject to be affected by body distortion, and so designed that the cylinder

(Concluded on page 354)

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Various Systems of Burning Pulverized Coal

Comparison Between the Bin, Air-Distribution and Unit Systems —Estimated Costs for Different Types of Installations

By C. F. HERINGTON*

IN any pulverized coal installation the following basic requirements are absolutely essential and should be strictly adhered to:

First—Dry coal.

Second—Coal pulverized to a degree of fineness found to be best adaptable to that particular kind of work. This degree of fineness will vary, depending upon conditions.

Third—Adequate combustion area surrounded by walls kept in an incandescent state to insure instantaneous deflagration of the fuel.

Fourth—Combustion air supplied in the proper quantities to furnish the necessary oxygen to burn the carbon in the fuel to CO².

Fifth—A steady unvarying supply of fuel thoroughly mixed with the proper proportion of combustion air and delivered into a combustion chamber at a low velocity.

It has proven and is a fact obvious to anyone, the lower the percentage of moisture in coal the better, for wet coal does not pulverize easily, it decreases the output of the pulverizer and increases the power requirements. After being pulverized it will also tend to choke the hopper by causing arching if the outlets are small, and it will cause the coal to pack more solidly and increase its angle of repose, and will decrease the length of time it can be safely stored without danger of spontaneous combustion.

In burning wet coal, a certain percentage of the heat units are employed in turning the moisture into steam and consequently correspondingly reduces the whole temperature as the steam finally passes out of the furnace as a superheated product.

The claim advanced that it is immaterial whether the coal is dried previous to or during combustion is erroneous, as there should be no loss of heat units in evaporating the moisture, and the fact that there is a lowering of the temperature in the furnace is sufficient to expel any doubts as to the proper method.

The finer the coal is pulverized, the more rapid and perfect the combustion, as it is easier to surround small particles of the fuel with sufficient air for their combustion than it is the larger particles. It is also a fact that the finer particles are more easily held in suspension and carried by the air current.

It is conceded that heat requirements vary, some operations requiring an instantaneous deflagration and a short flame such as would be required in a small furnace in which case coal should be finely pulverized. Other furnaces do not require the same fineness. One of the most successful pulverized coal plants on open hearths which has been in operation for over 10 years attribute their success to the fact that 99 per cent of their coal passes through a 200 mesh screen.

It is also conceded that the capacity of the pulver-

izer is increased in proportion to the coarsest product furnished and the power requirements per ton of coal pulverized will have been decreased in like proportion, but as the sole aim in pulverizing is complete combustion, then why stop at anything short of complete combustion requirements.

The fifth requirement as given above is acknowledged by all having any experience with pulverized fuel

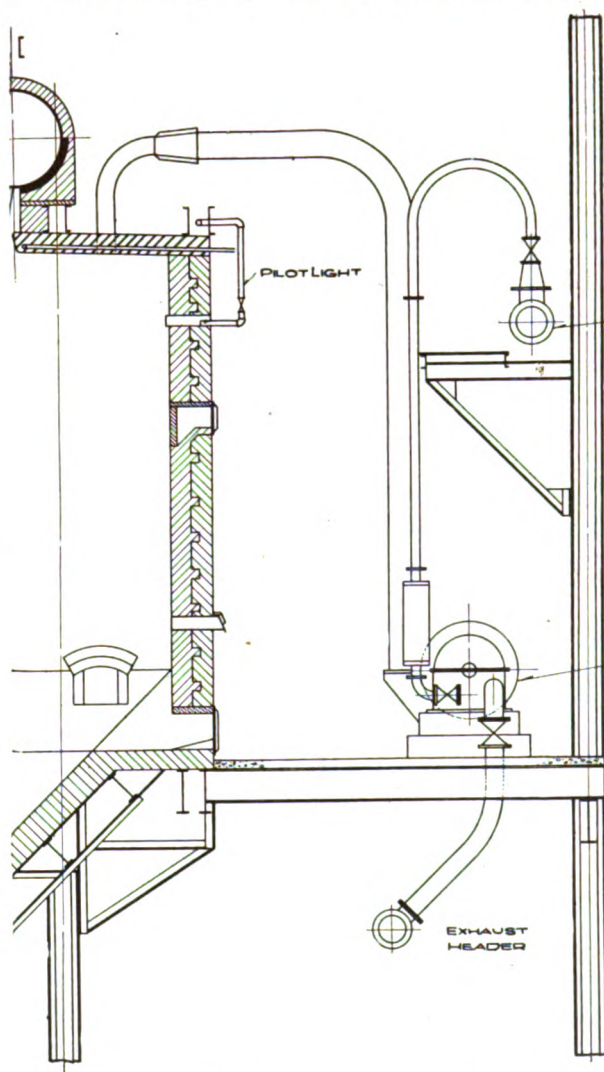


FIG. 1—Typical direct fired application.

to be necessary. A remarkable thing is, that everyone in the business claims to have the best and only successful way of accomplishing this result, either by means of a burner or a feeder, or a combination of both to fulfill this needful requirement. To date there are really only two systems used to form a thoroughly mixed proportion of pulverized coal and air, namely the bin system and the air distribution system.

*Engineer, Heyl & Patterson Co., Pittsburgh, Pa.

Bin System.

The bin system consists in having a separate individual pulverized coal storage bin located approximately close to each furnace which requires a separate screw feeder and individual motor, and the necessary secondary air apparatus to force the pulverized coal into the combustion chamber.

It is noticeable in the bin system that these varied pieces of apparatus as mentioned above are inadequate to form the necessary mixture of coal dust and air so that it has been found necessary in almost every instance to complete the cycle by a carburetor, burner, or so-called feeder to attempt to finish what the other apparatus has failed to do. For, no matter how well designed a screw feed from the bin may be, there is absolutely no way of actually determining at all times the exact amount of fuel being fed by the screw into a constant volume of air which forces the mixture into the furnace, and the reason for this is due to the fact that pulverized coal will hang up in these small bins. Even if this hang up lasts for only one minute, there is an appreciable difference when you remember that the combustion air does not stop for that minute. Assuming that your feeder is supplying coal at the rate of 400 lbs. of coal per hour to the furnace, the necessary air to be supplied for combustion for this amount of coal would be approximately 1200 cu. ft. per minute, so by stopping the feed of the coal dust into the furnace for one minute, you lose only 8 lbs. of coal but you furnish an excess of 1200 cu. ft. of air into the combustion chamber; and this operation need only be repeated two or three times per hour when the difference in the action of the furnace by this ununiform action can readily be seen, and production of the furnace is hampered and in many cases work is spoiled because of the unsteady temperatures being produced in the furnace.

Air Distribution System.

The air distribution system consists of pipes or

ducts through which the coal dust is carried in suspension in an air current induced by a blower. In order to carry coal dust in suspension through a pipe or duct, it is necessary that a minimum of 50 cu. ft. of air per pound of coal be used at a velocity of approximately 5500 cu. ft. a minute. This proportion of coal dust and air is not at any time sufficient for combustion and deflagration of this mixture will not take place even in a hot furnace without providing additional secondary air for combustion.

Sometimes the question is raised by writers on pulverized coal equipment that the power used in the air distribution system is excessive as compared with other systems, but this is not true, because the air used in distributing the pulverized coal to the furnaces is used as part of the necessary air for combustion and it only requires an additional $\frac{2}{3}$ more air to be furnished by the secondary air blower for complete combustion.

For example: Suppose we assume a plant having 20 heating furnaces each requiring 200 pounds of pulverized coal per hour and compare the motor requirements of the bin system with the air distribution system.

$$20 \times 200 \text{ lbs. coal} = 4,000 \text{ lbs. coal per hour.}$$

Bin System—Suppose the furnaces are located so that 10 bins will serve 20 furnaces, then there is required ten $1\frac{1}{2}$ hp. variable speed motors or 15 hp.

To convey the coal to the 10 bins will require at least 30 hp. motor, assuming a total distance of 600 feet from coal plant to farthest bin.

To furnish the secondary air necessary to bin, 4000 lbs. per hour in the 20 furnaces will require

$$\frac{4000 \times 180}{60} = 12,000 \text{ cu. ft. per minute blow-}$$

er which requires a 35 hp. motor.

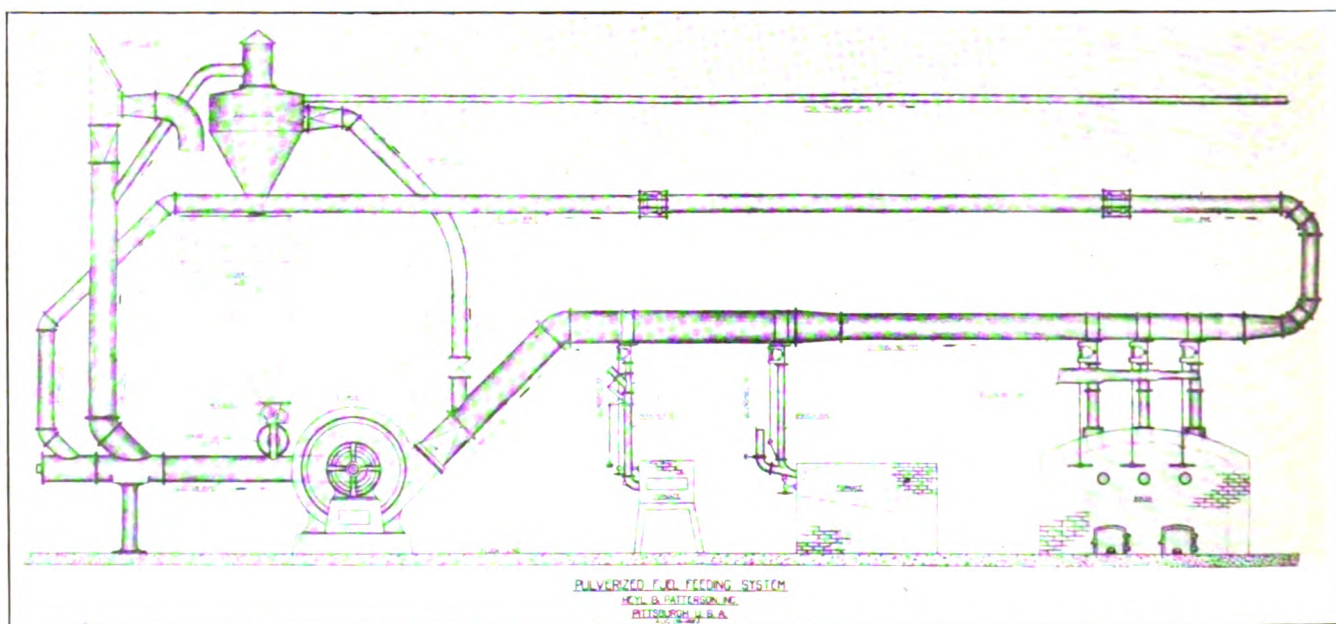


FIG. 2—General layout of air distribution system.

Air Distribution System—Distribution blower would be of 5,000 cu. ft. per minute capacity requiring a 35 hp. motor, and the secondary air blower would be 8000 cu. ft. of air a minute requiring a 20 hp. motor. The feed screws would require one 5 hp. motor.

Summary—Bin system motor requirements equal a total of 80 hp. whereas the air distribution system requires but 60 hp. to do the same work; also there are necessary in the bin system 12 different motors to take care of, as against three motors in the air distribution system, which shows a saving of 25 per cent less power required.

Another point to be considered is that no particular feeder or burner is found necessary as is in the bin system to blow the pulverized coal and air into the combustion chamber. A simple cast iron elbow or tee will suffice as there is being conveyed to this burner a real intimate mixture of coal dust and air which is not obtained in any other system with any so-called mixing chamber or feeders.

The Unit System.

As to the unit system which consists of a pulverizer and fan, pipe or duct leading direct into the furnaces, the dryer is eliminated as being unnecessary. Some of the objectionable features in the writer's opinion to this system are as follows:

First—Unreliable feed.

Second—Inability to properly adjust the combustion air to fuel.

Third—Excessive speed at which the pulverizer must operate.

Fourth—Wide variance of the fineness of the finished product.

Fifth—Excessive power requirements to perform the same work; and to illustrate this we give below a comparison between the power requirements of a unit pulverizer and an air separating pulverizer of five tons per hour capacity.

High Speed Unit Pulverizer	Air Separating Pulverizer
Speed 1480 Rpm.	Vertical shaft 114 Rpm.
Capacities ... 2391 lbs. per hour	6.47 tons per hour
% of Moisture in Coal.... 6.44%	5%
Kw. Hrs. per Ton of Coal 30.995	10.22
Degree of Fineness ...	
41.6 through 200	74.5 through 200
66.1 through 100	91.6 through 100
79.8 through 65	99.6* through 50

It is claimed by the manufacturers of this unit equipment that pulverized coal and air in correct proportions are intimately mixed in the pulverizer and this mixture reaches the furnace instantly it leaves the pulverizer. This mixing operation commences at the feed end of the pulverizer where coal and air enter together, and the pulverizing and the mixing go on together until the mixture leaves the pulverizer; having the appearance of a cloud of smoke. Then we can assume there is a combustible mixture in the pulverizer at all times, which mixture fortunately does not explode until it reaches the furnace.

The following figures given as to the comparative cost of the different plants are approximate only, and exception may be taken to some of the items. However, the writer believes they may be taken as showing the relation to the costs for the average plant.

Assuming a steel plant having eight heating furnaces, each furnace requiring 300 lbs. of pulverized coal

per hour for a working period of 10 hours. Each furnace located so that a separate bin is required and the farthest distance bin is located from coal plant being 500 feet.

Coal Plant Requirements.

Eight (furnaces x 300 lbs. = 2400 lbs. or 1.2 tons per hour—say a 3 ton per hour plant will be ample.

Hopper, feeder and crusher.....	\$ 4,000.00
Elevator, bin, dryer, dried coal bin.....	7,500.00
Pulverizer, exhaust, piping, collector.....	6,000.00
Pulverized coal storage bin.....	2,500.00

Motors for above machinery are included.

Building	3,000.00
Erection	7,000.00

\$30,000.00

Bin System

Eight 3-ton bins at furnaces.....	\$ 4,800.00
Eight controllers	1,600.00
Eight burners	1,600.00
Eight 1½ hp. motors.....	1,700.00
9-in. screw conveyors with motors.....	6,000.00
Secondary air blower and motor.....	2,500.00
Erection	3,500.00

\$21,700.00

Air Distribution System

Feed screws and motor.....	\$ 1,500.00
Distributing blower and motor.....	2,700.00
Distributing piping, fittings.....	3,000.00
Branch piping and burners.....	2,000.00
Secondary air blower and motor.....	2,500.00
Erection	4,000.00

\$15,700.00

To each of the above systems, the cost of the coal plant must be added, so that the total cost equals.

Bin System	\$51,700.00
Air Distributing System.....	45,700.00

Unit System

Hopper, feeder, crusher.....	\$ 4,000.00
Elevator to storage bin.....	3,500.00
Conveyors from storage bin to pulverizer hoppers	6,000.00
Eight pulverizer hoppers.....	2,000.00
Eight unit pulverizers and motors.....	20,800.00
Eight piping systems.....	2,800.00
Eight secondary air blowers and motors.....	4,500.00
Erection	4,000.00

\$47,600.00

In conclusion the author wishes to emphatically state that there has been no desire to show any one system to the disparagement of any other system, but to place before the readers the facts as have been observed in the experience of the author and to state his opinions without bias, leaving the reader to form his own conclusions.

Dirty Steam No Longer Necessary

(Continued from page 341)

Total water per hr. leaving boiler $1500 + 135 = 1635$ lbs.
Per cent of total water (carrying sulphate) to steam

$$\text{system } \frac{1500}{1635} = 91\frac{3}{4} \text{ per cent.}$$

In terms of soda ash— $91\frac{3}{4}$ per cent of 134 = 123 lbs. of sodium sulphate sent into the steam system for every 100 lbs. soda ash used in the feed water to the boiler.

Note—This calculation does *not* include the salts and dirt carried over as a result of a foaming boiler.

Graphic Method For Computing Heat Balance

A Convenient Way to Eliminate the Frequent Errors Resulting from the Use of Formulas When Computations of Boiler-Room Data Are Required

By F. A. SHORKEY*

THE computation of a heat balance by the use of the formulae involved requires lengthy calculations and if the formulae are not applied in a consistent manner, results in considerable error. Incorrect results are frequently obtained in the computation of boiler room data from the use of these formulae, due mainly, to misinterpretation of the various terms and the complexity of the mathematics involved.

The writer has spent considerable time and study in devising a series of charts with a view to eliminating these sources of error and also to facilitate and expedite the calculation of heat balances.

Basis of Chart Calculations.

These charts have been used in practice for some time and by checking them against a great many actual calculations, have been found thoroughly reliable for all practical purposes. They are intended both for predetermina-

*Assistant Engineer, Stoker Department, Westinghouse Electric & Mfg. Company, South Philadelphia, Pa.

tion of combined boiler and furnace efficiency in which the data is assumed and for actual boiler tests in which the data is known, applying equally well in either case, excepting Nos. 6 and 6A. These two charts are based on no CO being present and that the maximum theoretical CO_2 is 19 per cent. Since, in the former case, the flue gas analysis is unknown, it is assumed that there will be no CO and that 19 per cent will represent an average of the maximum theoretical CO_2 and, therefore, the charts will be correct for this case.

In the latter case, Charts 6 and 6A will be correct when the CO content is zero and the analysis of the fuel is such that the maximum theoretical CO_2 is 19 per cent, but any variation from these values will introduce an error, in proportion to the amount of variation, but which will be slight at the most, and may be ignored except where extreme accuracy is desired. In this case the loss due to heat in dry flue gases may be computed as outlined in a later paragraph.

All calculations are based on standard formulae uni-

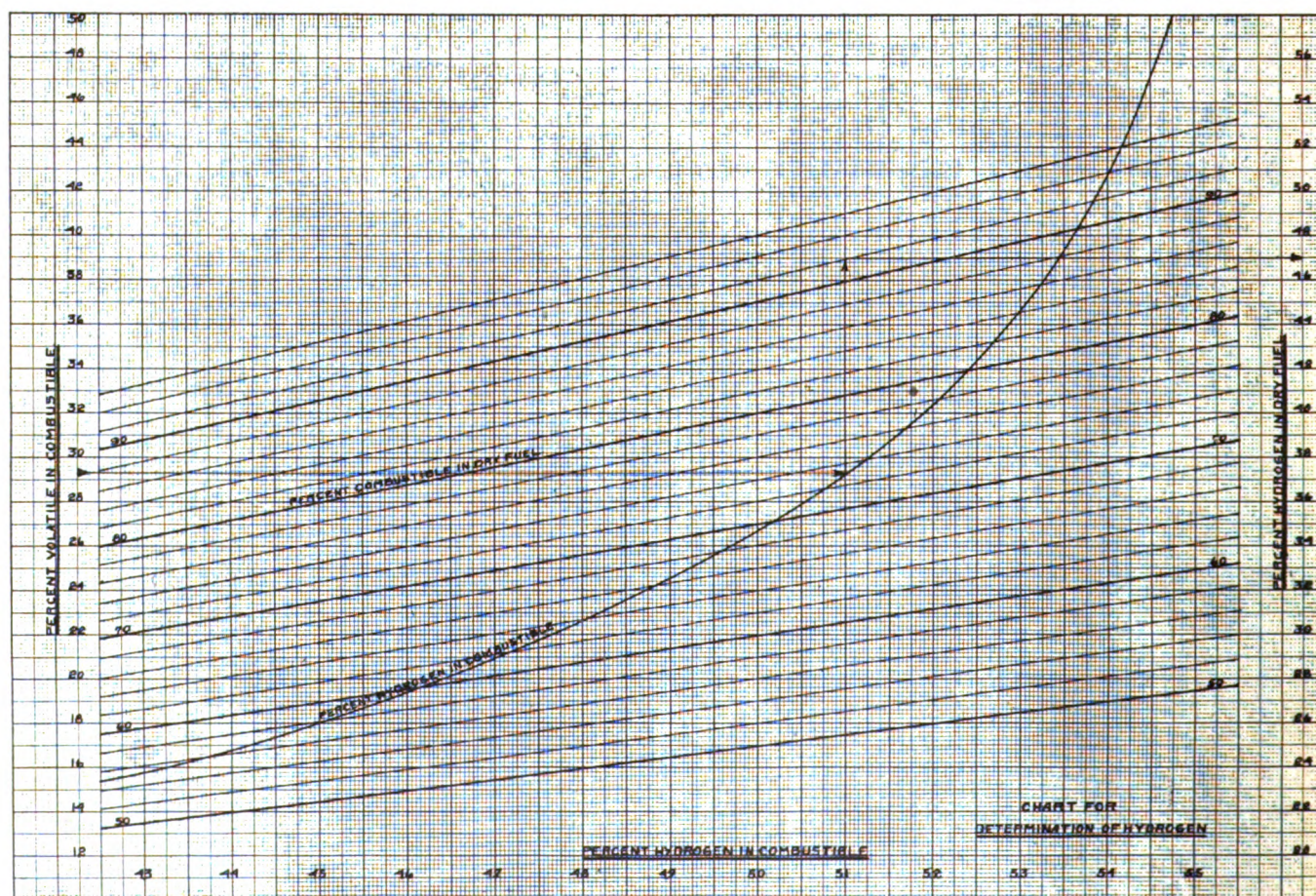


FIG. 1—Chart for determination of hydrogen.

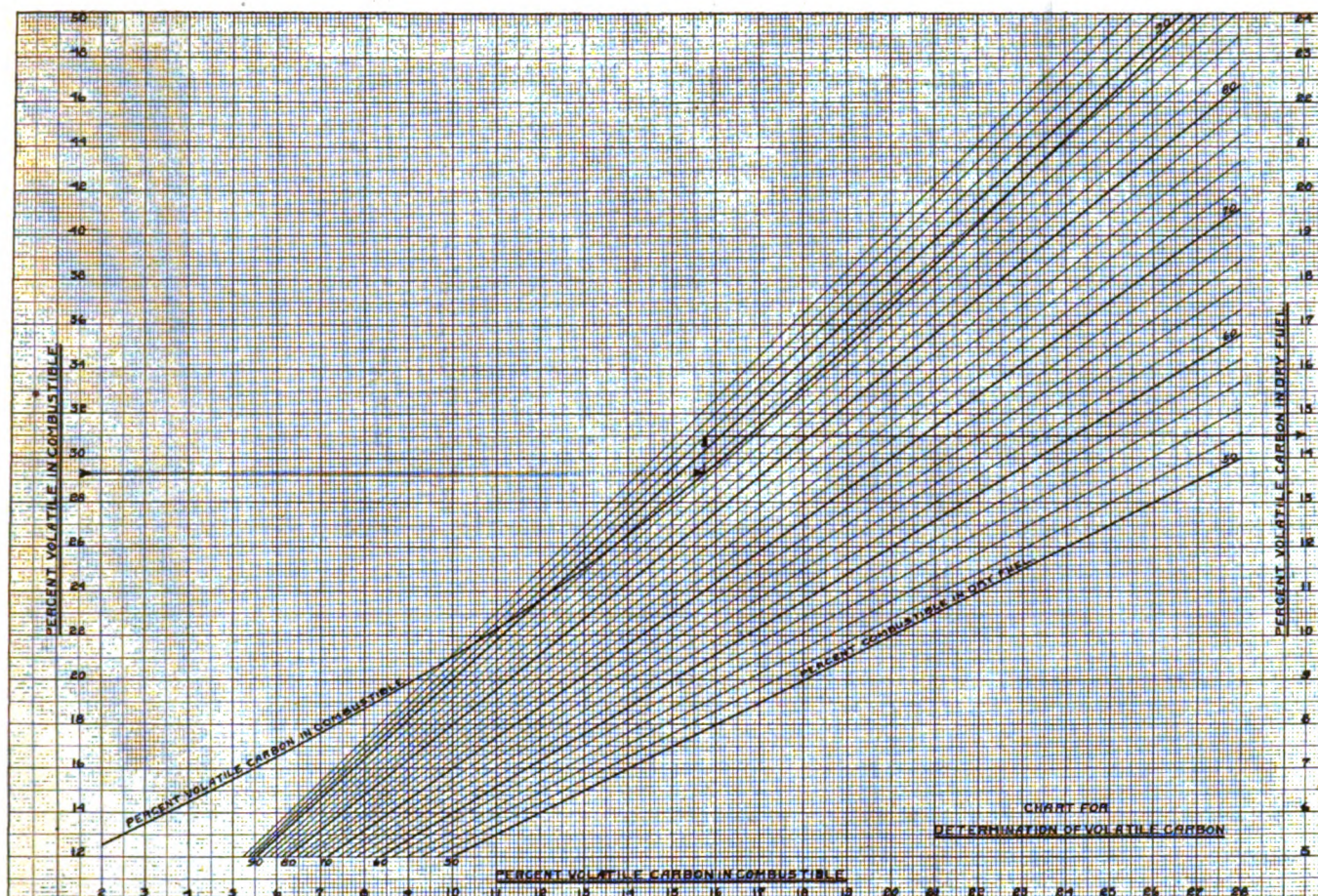


FIG. 2—Chart for determination of volatile carbon.

versally employed, the charts for determination of "hydrogen" and "volatile carbon" being empirically determined.

Example.

As an example assume that it is desired to predetermine the combined efficiency of a boiler and stoker, based on the following assumptions:

Combustible in refuse	20 per cent
CO ₂	14 per cent
Flue gas temperature	600 deg. F.
Radiation and unaccounted for.....	4 per cent

COAL ANALYSIS

F.C.	63.40	65.0
Vol	26.38	27.0
Ash	7.80	8.0
M	2.42	2.55
S	2.93	3.00
14150 Btu. as fired 14500 Btu. (dry)		

Let it be further assumed that the ultimate analysis of the fuel is unknown, necessitating the determination of that part of the analysis necessary to work up a heat balance, namely, hydrogen, total carbon and sulphur, all referred to the dry coal basis.

Preparation of Data.

Referring to the dry coal analysis the volatile in the combustible = $\frac{27}{65-27} = 29.3$ per cent. Total combustible in dry fuel = $65-27 = 38$ per cent.

From the left hand margin of Chart No. 1 at 29.3, the "Per Cent Volatile in Combustible," read to the right to intersection of the curved line marked "Percent Hydro-

gen in Combustible," then vertically to the intersection of the line marked "Percent Combustible in Dry Fuel" and then to the right hand margin where the "Hydrogen in Dry Fuel" is found to be 4.7 per cent.

In like manner, using Chart No. 2, read from 29.3 on the left hand margin to the point of intersection with the curved line marked "Percent Volatile Carbon in Combustible," then vertically to "Per Cent Combustible in Dry Fuel," then to the right hand margin where the volatile carbon in dry fuel is found to be 14.5 per cent, making the total carbon per lb. dry fuel = 65 (fixed carbon) + 14.5 = 79.5 per cent.

HEAT BALANCE

Loss Due to Moisture.

For each pound dry fuel there will be evaporated .0242
 $\frac{.0242}{1-.0242} = .025$ lbs. water or 2.5 per cent in terms of dry fuel.

From 600 deg. F. flue gas temperature on the left hand margin of Chart No. 3A, read horizontally to the point of intersection with 2.5 per cent moisture. From this point read vertically down to the lower margin where the loss is found to be 33 Btu. Reading horizontally to the right hand margin from the point of intersection of the vertical line with the line representing 14500 Btu. per lb. dry coal, the loss is found to be 0.23 per cent.

Loss Due to Burning of Hydrogen.

From 600 deg. F. flue gas temperature on the left hand margin on Chart 4A, read horizontally to the point of intersection with 4.7 per cent hydrogen. From this point read vertically down to the lower margin where the

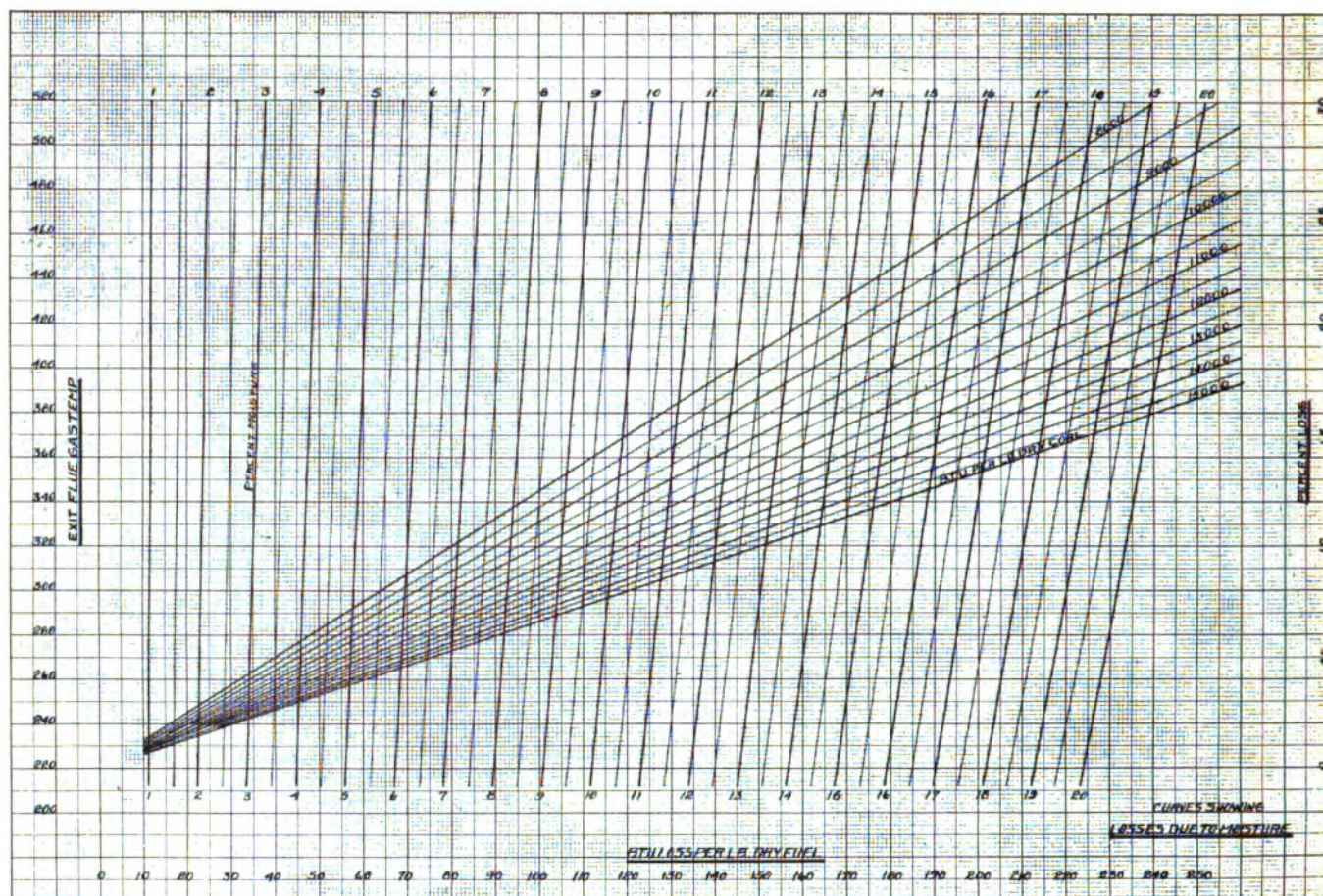


FIG. 3—Losses due to moisture.

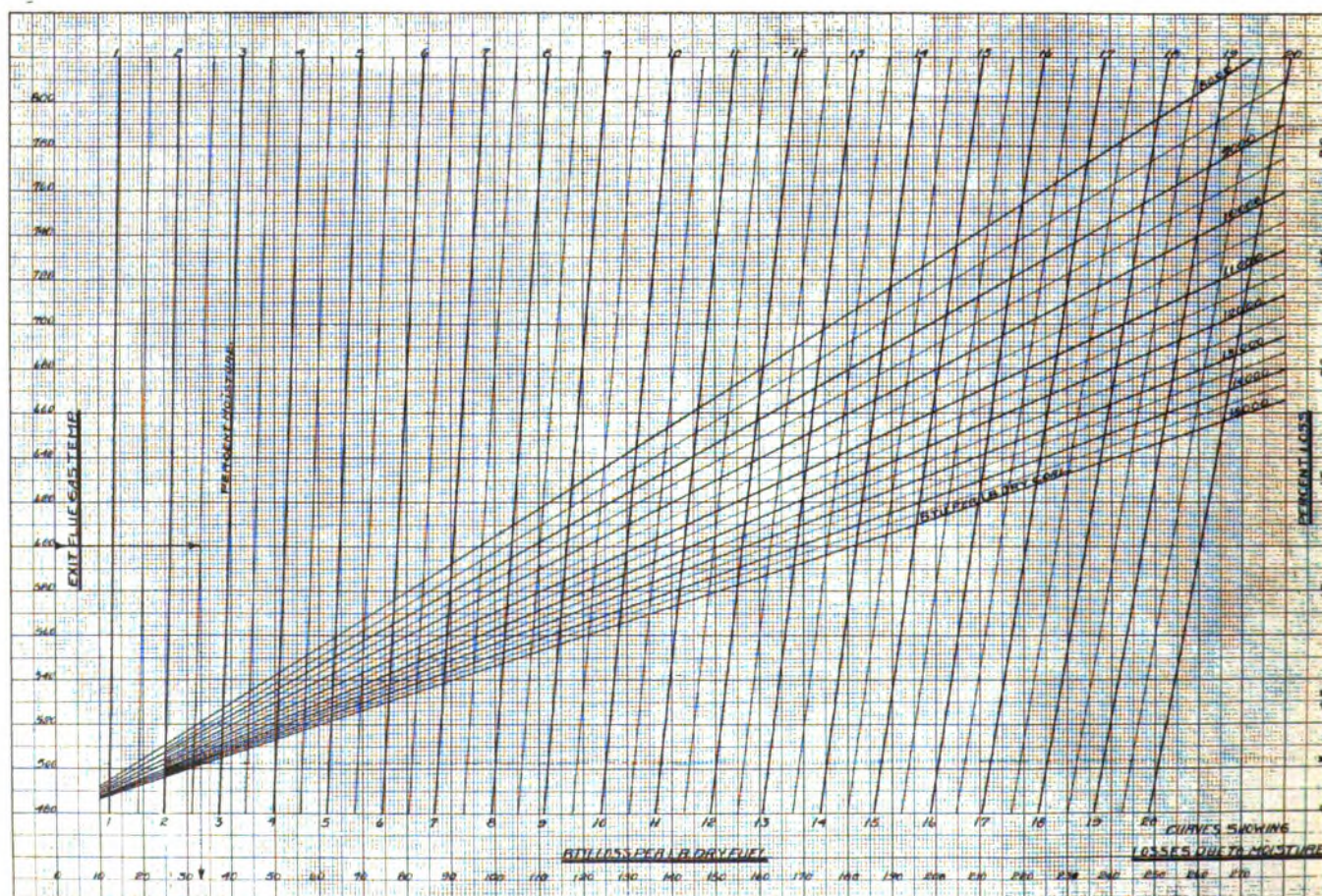


FIG. 3A—Losses due to moisture.

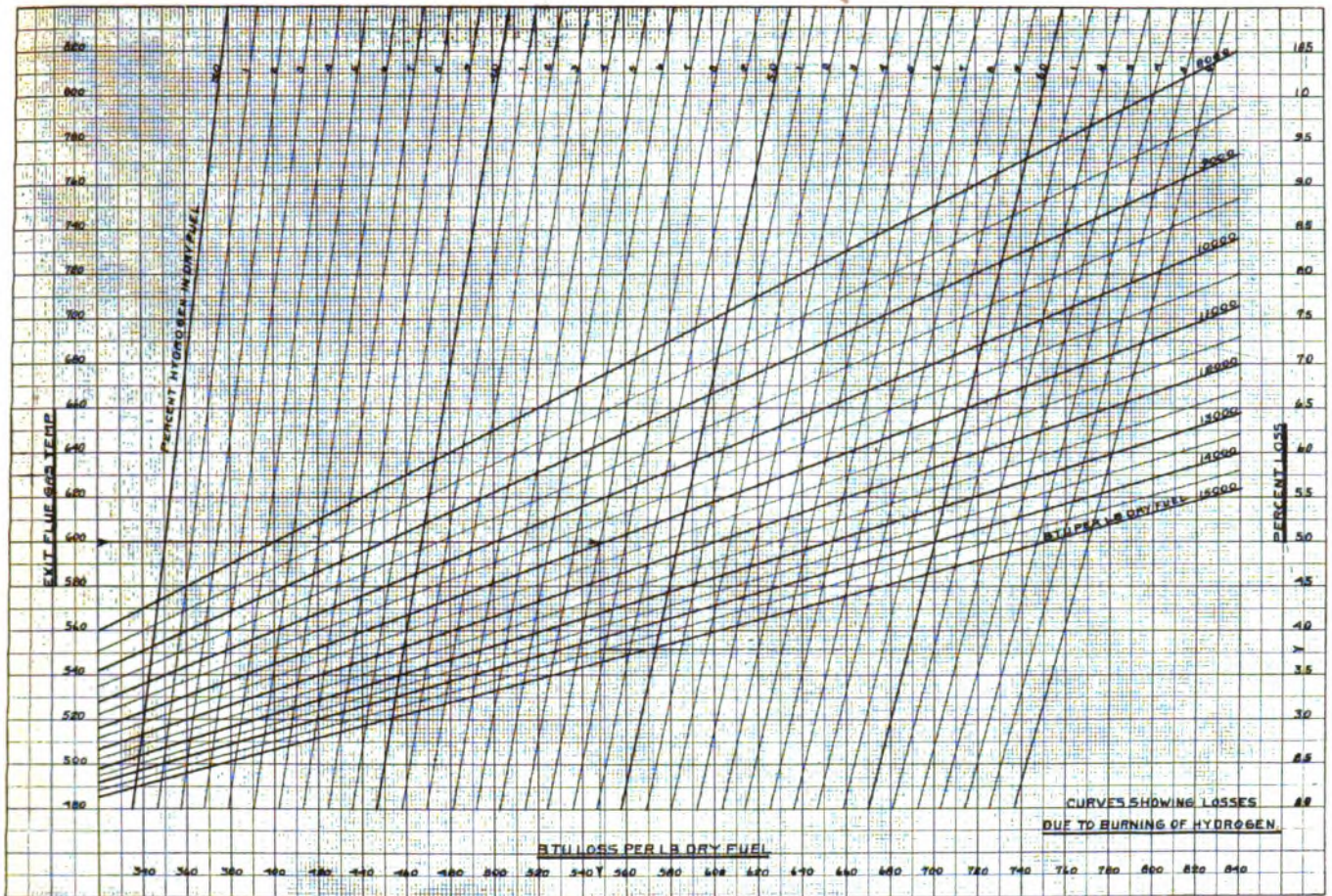


FIG. 4—Losses due to burning of hydrogen.

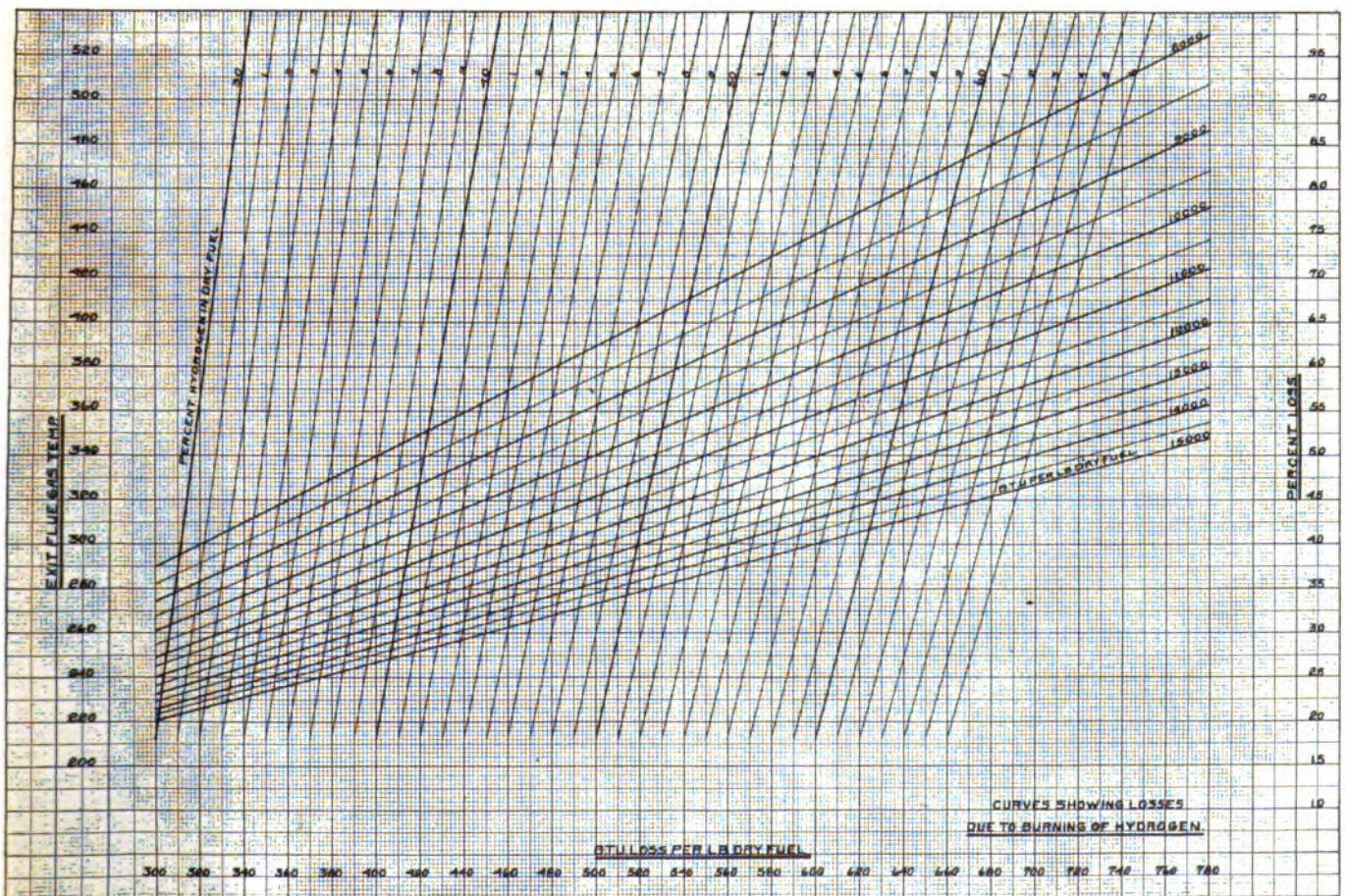


FIG. 4A—Losses due to burning of hydrogen.

loss is found to be 548 Btu. Reading horizontally to the right hand margin from the point of intersection of the vertical line with the line representing 14,500 Btu. per lb. dry coal, the loss is found to be 3.7 per cent.

Loss Due to Combustible in Refuse.

From 20 per cent "Combustible in Refuse" on the left hand margin of Chart No. 5, read horizontally to the point of intersection with 8 per cent ash. From this point read vertically down to the lower margin where the loss is found to be 295 Btu. Reading horizontally to the right hand margin from the point of intersection of the vertical line with the line representing 14500 Btu. per lb. dry fuel, the loss is found to be 2.04 per cent.

From this curve can also be obtained the correction for the carbon in the refuse and sulphur equivalent. The amount to increase or decrease the total carbon content for obtaining the flue gas loss will be found in this example by reading vertically from the Btu. loss or 295 on the lower margin to the line marked "Per cent Sulphur in Dry Fuel," which, in this case, is 3 per cent, then to the left hand margin to ordinate marked "Correction for Equivalent Carbon Burned," where the correction is found to be minus .0035 lbs. This is the correction for both sulphur content and carbon in the refuse. If, for any reason, it is desired to know the "Carbon in the Refuse," it can be found by reading to the extreme left hand margin from the point of intersection of the vertical line with the line marked "Lbs. Carbon in Refuse per Lb. Dry Fuel" and which is found to be 0.02 lbs.

Loss Due to Heat in Dry Flue Gas.

From 600 deg. F. flue gas temperature on the left

hand margin read horizontally to the right to the point of intersection with 14 per cent CO_2 , then vertically to the point of intersection with the line of "Total Carbon Burned per lb. Dry Fuel," which in this example is 79.5 per cent or 0.795 lbs. minus 0.0035 lbs. (correction as explained under "Loss due to the Combustible in Refuse") or 0.7915 lbs. From this point read horizontally to the right hand margin where the loss is found to be 1825 Btu., and from the intersection of this horizontal line and the line representing 14500 Btu. per lb. dry fuel reading vertically to the top margin the loss is found to be 12.6 per cent.

SUMMARY OF HEAT BALANCE

	Btu.	Per Cent
Loss due to moisture.....	33	.23
Loss due to moisture formed in burning hydrogen	548	3.78
Loss due to combustible in refuse.....	295	2.04
Loss due to heat in dry flue gases.....	1825	12.60
Loss due to radiation and unaccounted for.....	580	4.00
Heat absorbed by boiler.....	11219	77.35
Total.....	14500	100.00

To calculate a heat balance from a boiler test in which the complete flue gas analysis is known and extreme accuracy is required, it would be necessary to compute the loss due to heat in dry flue gas by the formula

$$.24(T-t) \times \frac{11\text{CO}_2 - 8\text{O}_2 - 7(\text{N}-\text{CO})}{3(\text{CO}_2 - \text{CO})} \times \frac{S}{(C - 1.833)}$$

where T = Temperature of exit gases.
 t = Temperature of air entering furnace.
 C = Weight of carbon burned per lb. dry fuel.
 S = Weight of sulphur per lb. dry fuel.

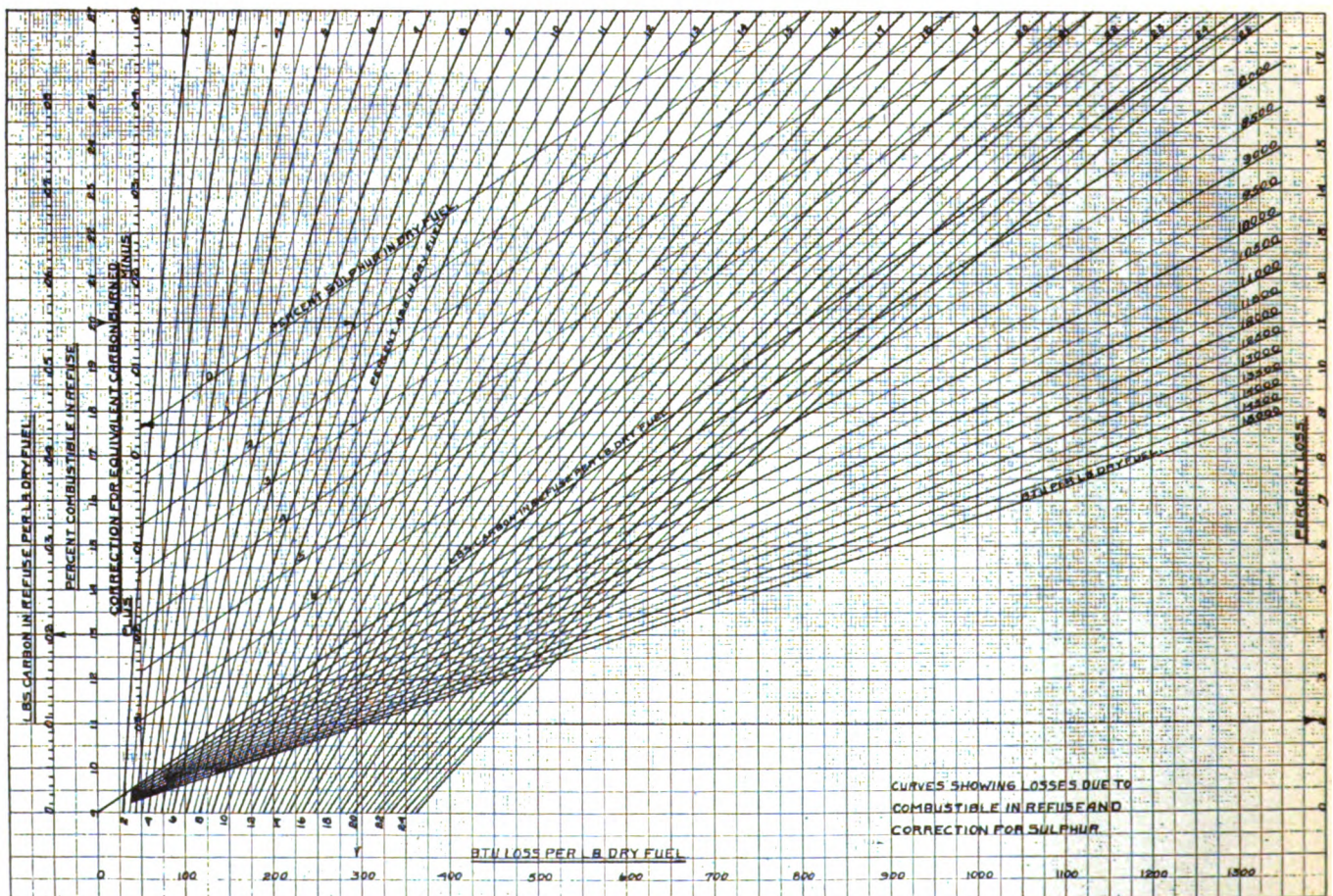


FIG. 5—Losses due to combustible in ash and sulphur correction.

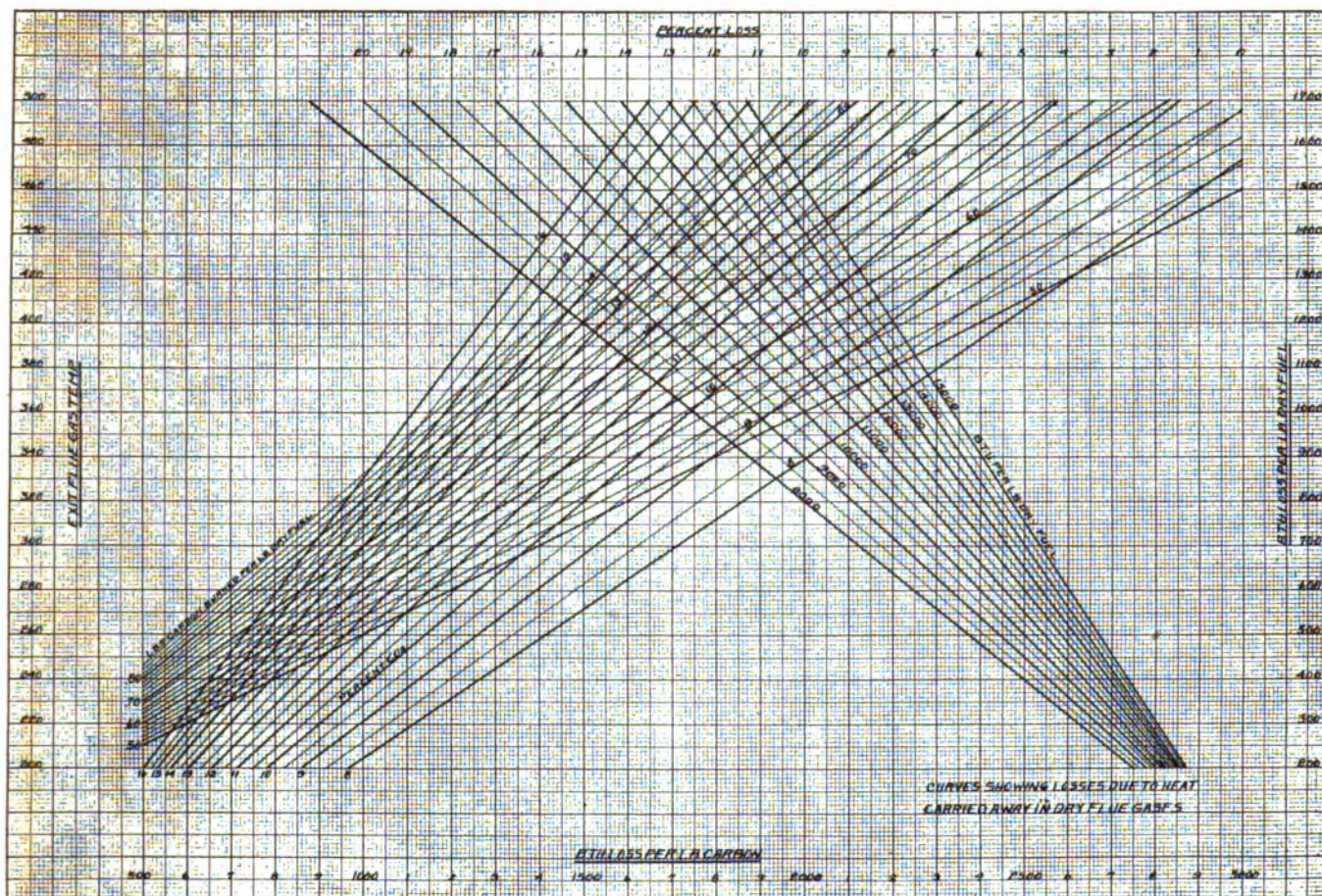


FIG. 6—Losses due to heat in dry flue gases.

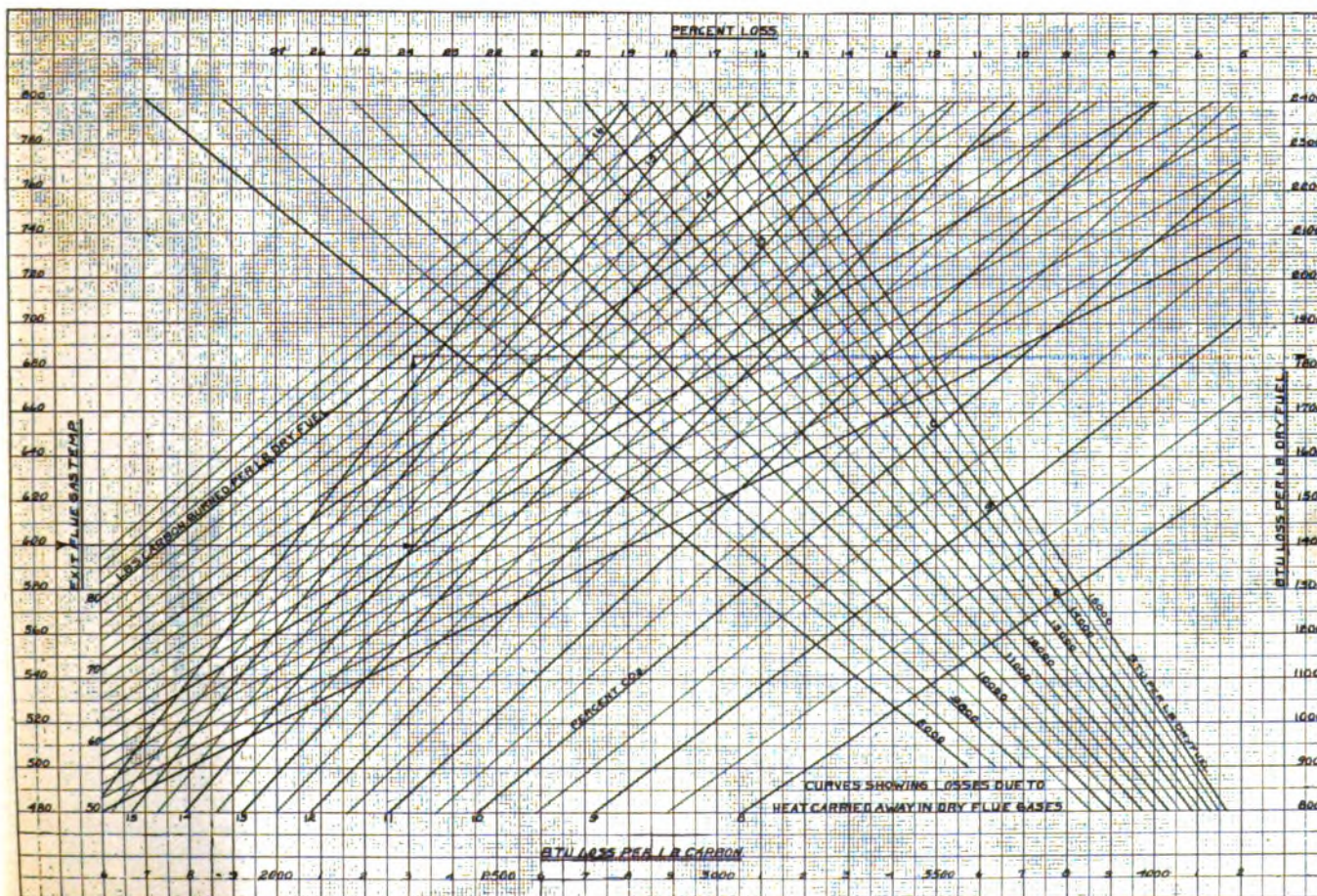


FIG. 6A—Losses due to heat in dry flue gases.

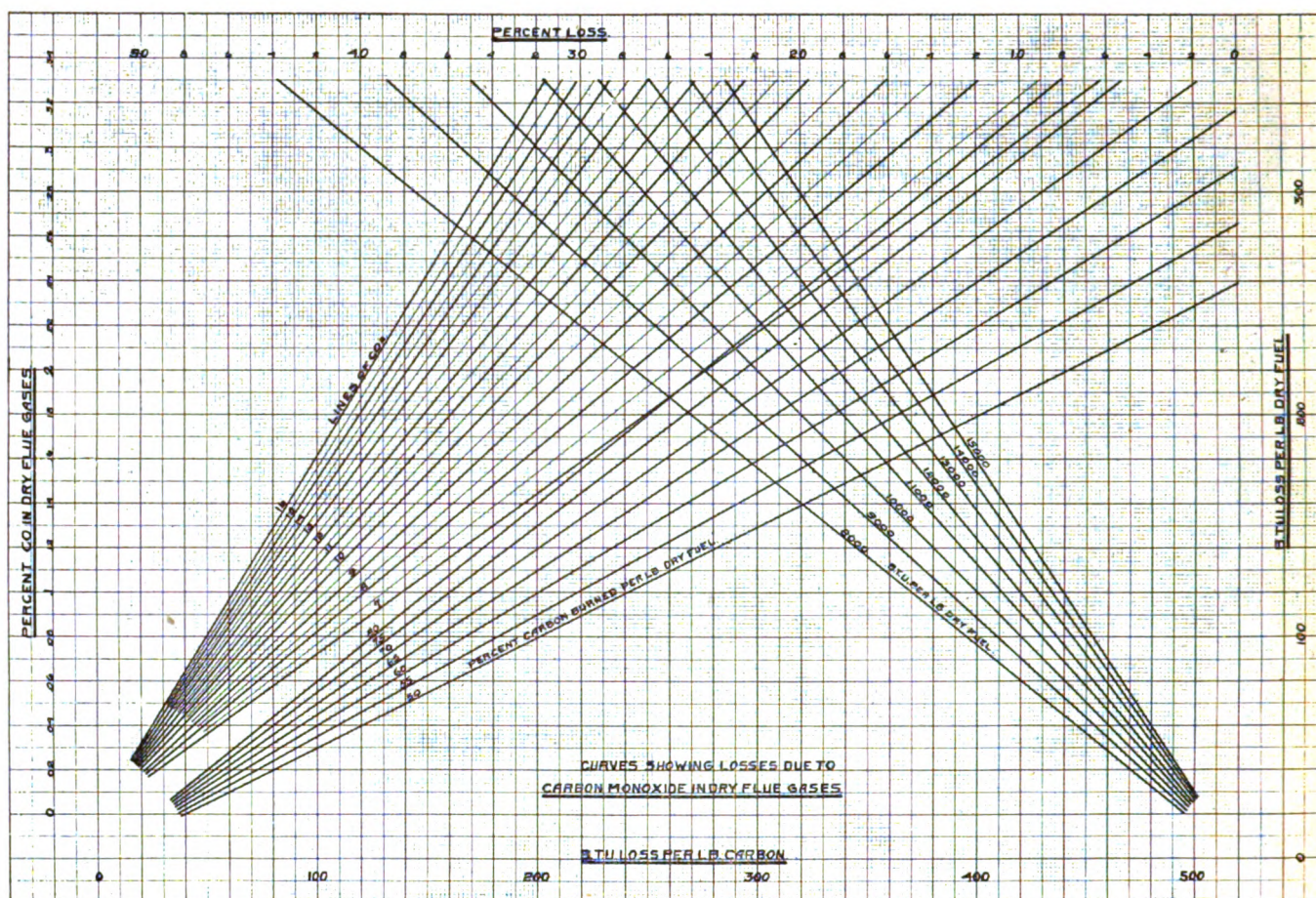


FIG. 7—Losses due to CO in dry flue gases.

As stated in a previous paragraph, the error introduced by the usual slight variation from the assumptions on which Charts 6 and 6A were based will be small and can, in most cases, be ignored, eliminating the necessity of using the above formula. The remaining curves will apply in any case and should be used in the manner described above.

Loss Due to Incomplete Combustion of Carbon.

Whenever CO is present, Chart No. 7 is used to determine the loss and is used in the following manner:

From the per cent CO on the left hand margin read horizontally to the right to point of intersection with CO line, then vertically to line of "Total Carbon Burned" (Total carbon—correction for carbon in refuse and sulphur) and horizontally to right hand margin, which will show the Btu. loss. From the point of intersection of this horizontal line and the line representing the Btu. per lb. dry fuel, read vertically to top margin for per cent loss.

Stop Check Valve vs. Triple Duty Non-Return

(Continued from page 344)

around the dash-pot piston may always expand first when subjected to temperature. Very few steel plants are supplied with absolutely pure feed water, therefore, there is always a possibility of dirt passing through the valves along with the steam. The dash-pot chamber and moving elements should be made to by-pass as much of the steam enclosed in this chamber as possible so that the least amount of new steam carrying dirt will

have to enter this chamber. Another very valuable feature is to have a valve in which the internal parts can be moved mechanically by some means other than the steam pressure before cutting the boiler into service.

Oil and Steam Engine Costs for Small Towns

Comparative costs of oil and steam engines for furnishing a water supply and electricity in small towns were given recently in a paper by George T. Prince, consulting engineer, presented to the Iowa Section of the American Water Works Association.

Population	Probable Annual Output—in Kw.-Hr.	Cost of Power Plant	
		Steam	Oil
1,000	198,000	\$ 35,300	\$ 31,500
2,500	648,000	54,650	53,200
5,000	1,300,000	82,000	91,300
10,000	2,700,000	117,500	103,900

Annual Maintenance and Operating Expense		Unit Cost per Kw.-Hr.	
Steam	Oil	Steam	Oil
\$13,874	\$ 8,992	\$0.070	\$0.045
19,798	15,063	.030	.0234
30,405	26,492	.023	.0204
49,348	39,303	.0183	.0146

Life of engines is assumed at 15 years, all other property, 25 years. Price of coal is taken at \$8 per ton for 1,000 and 2,500 population towns; hand firing; evaporation, 6-1. Price of coal, \$7.50 for 5,000 population; mechanical stokers; evaporation, 8-1. Price of coal, \$7 for 10,000 population; mechanical stokers; evaporation, 8-1. Price of fuel, 6c per gallon. Price of lubricating oil, 60c per gallon.—*Engineering News Record*.

CURRENT TECHNICAL DIGEST

President Farrell Addresses Convention

President James A. Farrell of the United States Steel Corporation addresses the closing session of the Foreign Trades Convention in New Orleans. As chairman of the Foreign Trades Council since its organization Mr. Farrell is probably the most qualified speaker on the subject, "The Shipping Situation of the World."

Co-operation is the basis of his solution of present Shipping Board operation losses and difficulties.

Germany's rapid recovery from war conditions was stressed. Since 1918 Germany has built 1,500,000 tons of new ships, and within a very short period will attain third place in ship ownership. To quote President Farrell:

"It should be obvious that the losses of operation of American ships come not from a surplus of modern ships, but from a lack of co-operation on the part of all owners, foreign and domestic, to stabilize a business in which all are suffering. I am confident our foreign rivals would recognize the desirability of co-operation by all maritime countries in disposing of obsolete tonnage and deciding on the amount of tonnage to be used in the market, so as to balance the supply of ships with the demand, thereby stabilizing rates not merely to the advantage of the operators, but even more to the advantage of the traders of the world.

There is an opportunity for a trading relation. The board admittedly has many more ships than it hopes or needs to sell to Americans. Retain sufficient for our needs, and sell to foreigners the surplus. Internationally there can be built a basis for the sale of the board's ships at the world's market price in a manner that will give to the American ship owners a paying basis on the volume of trade they seek. The board would be in position to say to the American company in a given trade route:

"Co-operate with the foreign lines now competing with you; furnish one-half of the tonnage required to move the freight over a particular route; each to act as loading and discharging agent for the other; each plan which ships of the two companies will operate on an alternate schedule, and thus will receive an equal portion of the business moving in both directions. In brief, replace unbusinesslike competition with sound co-operative operations; which will substitute profits for losses, and will demonstrate to the American in-



vestor the advantage of owning shares in American ships, particularly at the low market prices prevailing today. The Shipping Board to sell to the American company the ships required for its share, and sell to the foreign company such ships as may be required for their share. The price of the ships to be the same to each."

The foreigner would receive the advantage of replacing obsolete ships with modern ships at a fair price; they would know within reason the elements with which they and their American partner would have to contend; they would know that they would no longer have to match their reserves against those of the United States Treasury, and best of all, the available ships would be leveled down to the number the world trade requires, through scrapping such of the Shipping Board fleet as is obsolete and the scrapping of such foreign tonnage as is in a similar condition.

The clear purpose of the act of 1920 was to develop our fleet under private ownership and operation. Already considerable progress has been made. Private American ship owners owned, on April 1 last, a total of 5,962,133 tons, gross register, of ocean-going shipping. This is exclusive of 2,723,857 gross tons employed on the great lakes. On that same date the shipping. This is exclusive of 2,723,857 gross tons employed of which probably one-third is fit only to be scrapped.

The suggestion recently made that the Shipping Board should engage in the direct operation of its vessels is contrary to the spirit and purpose of the act of 1920, and fraught with danger to the merchant marine."

Iron Age, on page 1321 of May 10, features a paper titled "Some Effects of Zirconium in Steel," by F. M. Becket, directing head of the Electro Metallurgical Company of America; this paper was read before the American Electrochemical Society at the spring meeting.

Numerous experiments on the reduction of zirconium ores and the preparation of zirconium alloys were conducted at the Niagara Falls plant of the Electro Metallurgical Company during the period of a few years immediately preceding the entry of the United States into the World War.

Early in the year 1918, having been influenced by apparently authentic reports concerning the use by Germany of remarkable ordnance steels containing zirconium — reports which were later considered groundless, if the author has been correctly informed — the War Industries Board decided upon an intensive program of experimentation with zirconium in steel for light armor, the direct object being the earliest possible large-scale production, and the Electro Metallurgical Company was requested to furnish zirconium alloys with this end in view.

Concise News from Iron Trade Review

May 3

Pig iron production in April was the greatest both in gross tonnage and in daily average in history. The total production of coke iron was 3,547,012 tons compared with 3,523,595 tons in March.

Prices in Europe have been boosted by the Ruhr conflict. The effect of the French occupation of Germany's industrial center is outlined in an exhaustive story by Mr. H. Cole Estep, European manager, Iron Trade Review. It is shown that the continuance of the occupation is diverting much business to America and England. British producers are dominating the export situation.

Using Powdered Coal for Melting Furnaces in the Production of Malleable Iron." An exhaustive article on the use of pulverized fuel in air furnaces by E. E. Griest of the Chicago Railway Equipment Company appears in the May 3 and May 10 issues. Summaries of power consumption, as well as analyses of suitable coals are given.

The exhibition of the American Foundrymen's Association held in Cleveland is described in full and illustrations of some of the attractive booths are shown in the May 3 issue.

May 10

The pressure for steel is unabated but the trend toward more conservative buying is more marked. The rate of steel ingot output in April sets a new high record. For the first time in many months there have been few, if any, fluctuations in the prices of pig iron and finished steel.

The weekly cable to Iron Trade Review shows that European prices are still falling. The buying in Europe of American coke has practically ended. A drop in French markets is checking imports.

The details regarding a successful apprentice course developed by the Reed-Prentice Company, Worcester, Mass., is described by Herbert R. Simonds. The form of apprentice agreement, a table of apprentice wages and other details are given.

Another exclusive article from Iron Trade Review's European staff outlines the German viewpoint on the Ruhr situation. It shows that producers in the Ruhr are selling present mill stocks and future rollings to foreign interests to prevent seizure of accumulations by French.

A concise but comprehensive review of the technical sessions of the American Foundrymen's Association convention appears in the May 10 issue. The report of the discussions at the meeting of the American Electrochemical Society also are given.

FOR MAY 17

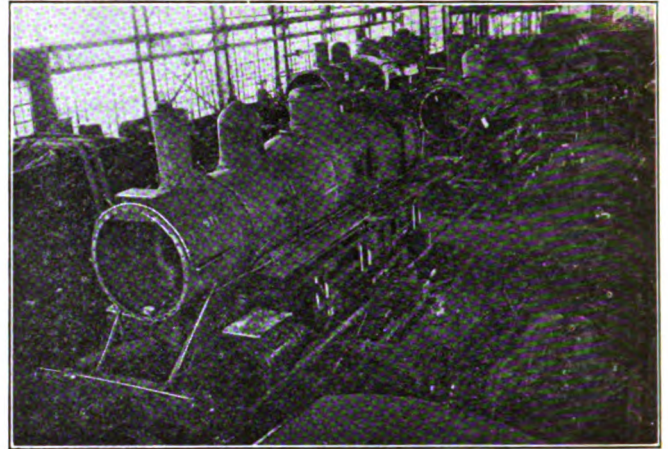
Slowing Down of Buying Takes Little Pressure off Mills from Bookings—Underlying Absorption of Material is Tremendous—Production Continues at Top Speed and More Furnaces Resume—300,000 Tons of Rails Placed.

Wave of Postponements of Large Projects in Greater New York, Spreading to Other Centers—High Material and Wage Costs and Delayed Deliveries Cause This Development—Car Shortage is Diminishing.

Loss of Shipbuilding and Repair Contracts by Yards Specializing in Government Work Compels Plant Officials to Enter New Field as a Means of Pre-

serving Their Organizations—Success is Encouraging. By Herbert R. Simonds.

Progress in South America Linked Closely with Development of Available Water Power — Argentina and Brazil in the Lead — In Far East Japan Offers Greatest Opportunity for Future Work. By C. G. Schluederberg.



Locomotives under contract-repair.

Data on Automotive Castings Are Compiled from Questionnaires Returned by 16 Plants—For Engine Cylinders Scrap Steel of Fairly Good Section Such as Rails Charged to Mixture Produces Best Results. By H. B. Swan.

Growing Use of Scientific Foundry Methods Has Become an Important Factor in Foundries of Great Britain—Wide Range of Castings Produced—Casting Temperatures Are Shown to Have Decided Effect Upon Physical Properties. By Percy Longmuir.

New Construction Departing from Usual Arrangement of Electrodes Gives Greater Flexibility of Operation — Steel-making Furnace Now Being Built and Having 60 to 80-ton Capacity Is Provided With Eight Electrodes.

Chamber of Commerce of United States in its Annual Meeting States Present Law is Not Adaptable to Changing Conditions — Favors Establishment of a Court of Tax Appeals — Reaffirms Open Shop Stand.

May 24

The railroads are continuing their heavy pressure on steel mills for supplies. Production is being maintained at a high rate. Significance is attached to the adoption of the 8-hour day in continuous operations in a number of Youngstown steel mills.

Joseph Horton, British correspondent for Iron Trade Review, surveys the British ferromanganese trade, tracing the history of this branch of the iron industry and listing all makers of British ferromanganese as well as their American representatives.

An authoritative article on detinning scrap electrically is presented by C. E. Williams, C. E. Sims and C. A. Newhall.

An authoritative report of the British Iron and Steel Institute meeting appears in this issue. The effect of the Ruhr occupation was discussed. The technical program covered papers on fuel economy and production of power in steel plants. Reports of the supplymen's triple convention at Cincinnati and also the meeting of the purchasing agents in Cleveland are covered in this issue.

General Electric Review, May, 1923

Contents

	PAGE
Frontispiece—Sir Joseph Thomson Examining a 20-kw. Plotron	248
Editorial — Sir Joseph John Thomson Visits Schenectady	249
Electricity Masters Paper Making —	
By R. H. Rogers.....	250
Water Cooled Resistors—By H. F. Wilson.....	258
40,000 Kva. Shawinigan Falls Waterwheel Generator — By J. R. Johnson.....	263
Direct Current Locomotives for the Imperial Government Railways of Japan—By A. Fredenberg, Jr.	268
30-kilowatt 15,000-volt Rectifier for the United States Navy — By A. Schmidt, Jr.....	276
Charles A. Coffin Foundation—	
By W. W. Trench.....	278
Studies in the Projection of Light. Part IV—	
By Frank Benford.....	280
The Agricultural and Industrial Features of Priest Rapids—By H. J. Pierce.....	291
Electric Propulsion for the New San Francisco-Oakland Terminal Railway's Ferryboats —	
By L. Rask.....	294
Cooling of Turbine Generators—Part III—	
By A. R. Smith.....	298
Arc Welding of Cast Iron—Part II—	
By W. H. Namack.....	304

A. I. E. E. Meeting

A spirit of optimism and expansion marked the Pittsburgh meeting of the American Institute of Electrical Engineers held April 24-27. Nearly 1200 engineers from every section of the United States were present, and all reflected their enthusiasm over the immediate future of electrical development.

The sub-committee on grounding of protective devices, E. C. Stone, chairman, reported definitely toward the grounding of neutrals on large transmission systems. The use of arc-suppressors has been abandoned. H. H. Dewey's paper dealt with the general considerations covering this subject.

W. W. Lewis presented a descriptive performance of the Peterson coils installed by the Alabama Power Co., under title of "The Neutral Grounding Reactor."

R. W. Atkinson held a brief for the insulation of over-head lines for over-voltage—referring specifically to a 33,000 v. cable installation in Los Angeles which had operated two years.

Dr. Charles P. Steinmetz invited discussion of his paper on "Frequency Conversion by Third Class Conductors and Mechanism of the Arcing Ground and Other Cumulative Surges."

A. H. Babcock furnished interesting test data com-

paring locomotive operating costs on the Southern Pacific; using fuel oil, compared with regenerative braking electric locomotives.

Mr. Cary T. Hutchinson in an analytical discussion furnished the following tables:

TABLE II — RELATIVE HEAT REQUIREMENTS, STEAM AND ELECTRIC FOR SAME SERVICE

	Steam	Electric
1. Weight of train, tons.....	1,000	860
2. Energy at driver, total kw.-hr.....	4,950	4,250
3. Energy at driver, from oil, kw.-hr.....	4,950	2,970
4. Energy at driver, from oil, per cent....	100	60
5. Heat required at drawbar per kw.-hr., Btu.	109,000	45,500
6. Total heat required (10' X Btu.).....	540	135
7. Total heat required, per cent.....	100	25

Mr. F. V. Andrea, Chief Engineer, Southern Manganese Corporation, developed his observations of a large number of operations, under title "Some Problems of Electric Furnace Operations" with the conclusion that the transformation of electrical energy into heat energy takes place in an arc passing through an atmosphere of vapors under pressure.

1. The larger the cross-section of the conductor the larger the skin effect. This effect is appreciable at frequencies of 60 cycles for conductors greater than ½-in. diameter.

2. Skin effect is higher in straps than in tubes of equisectional area with subsequent higher power loss.

3. Distribution of the current over the sectional area is not affected by the inductive disposition of the conductor, since the internal inductance is unaffected by the mutual inductances.

4. Inductive reactance may cause considerable voltage drop in the electrode leads.

5. The larger the diameter of the conductors the less the inductance.

6. The farther apart the conductors the larger the inductance.

7. When inductive reactance expressed as per cent reactance drop amounts to 20 per cent or more, the actual volts drop in the line increases rapidly with decreased power factor.

Mr. E. T. Moore took exceptions to Mr. Andrea's undue emphasis upon balanced loads between conductors and other parts of the apparatus. Fluctuations rather than load unbalances were detrimental to the central stations in Mr. Moore's opinion.

Mr. Frank Hodson dwelt upon the tendencies shown in large electric furnace units similar to the new Ford 60-80-ton furnaces.

Electricity for mill-heating was covered in a paper by C. T. Guilford.

Professor Malcolm McLaren, of Princeton University presented a very elaborate investigation of the Philadelphia Electric Company with regard to lighting disturbances on low tension distributing systems. Electrical World May 5, 1923, pages 1019-1031.

TABLE I—WORK DONE AT DRIVERS, STEAM DRIVE

		Eastbound 1,000		Westbound 1,000
1. Weight of train, tons.....				
2. Work at drivers, kw.-hr.:				
(a) Grade	2,760	....	985	....
(b) Curve	250	....	25	....
(c) Track	690	3,700	240	1,250
3. Available for regeneration (a) - (b-c) .....	....	1,820	....	720
5. Deliverable at driver, 80 per cent.....	....	1,365	....	540
6. At driver as per cent of total work.....	....	29.4	....	439
7. Same, for round trip, same tonnage both ways.....	....	30.6	....	34.4

When and Why Does Electricity Kill?

"Science and Invention" for May illustrates the dangers and vagaries of electric currents, so universally handled that familiarity often breeds contempt. Mr. McCabe has brought the facts forcibly home.

Electricity is today one of the greatest servants of man. The automobile, telephone, trolley, radio, submarine are all inert mechanical devices till fed with the subtle force that makes the whole world go 'round. But every so often it strikes back, sudden and swift as the lightning that mothered it, and a human life is snuffed out, perhaps a part of the price mankind must pay for services rendered. But the how and why has survived countless controversies.

Tell the average person that 1,800 volts are used to electrocute criminals. Then tell them the coil in their car develops over 15,000 volts, and they stand aghast. It is enough to kill, but it does not, except in unusual conditions, where the shock to the nervous system and not the current flow itself causes death.

To state offhand that a certain voltage will kill means nothing; there are a number of factors that must be taken into account when considering death by electricity. A heavy flow of current through the body paralyzes the muscles and vital organs, destroys the nervous system and may disintegrate the blood. The extent of these injuries depends chiefly upon the amount of energy expended in the body. Hence, we might rate the killing energy in watt seconds. But we find that at higher voltages and frequencies we can expend harmlessly an amount of current in the body that would cause death at lower voltages or frequencies. As an approximate rating of a minimum current value that will produce death, it has been found that one-tenth ampere through a vital organ will result fatally.

"A voltage drop of 2 to 3 volts within the body, with one-tenth ampere, may kill," says Dr. F. Wenner, of the U. S. Bureau of Standards.

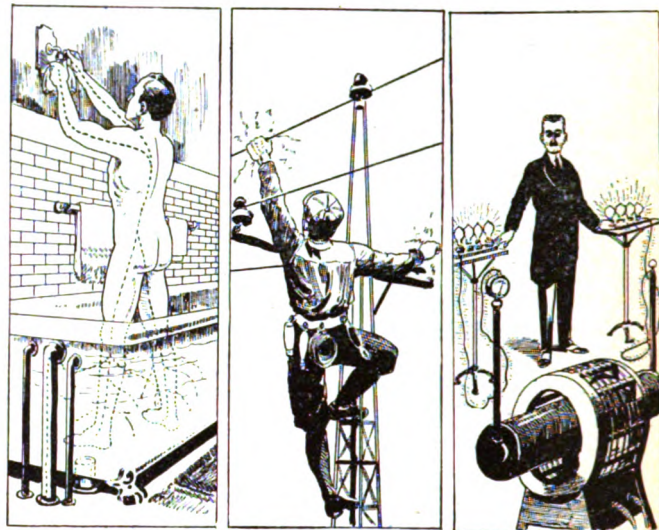
The voltage necessary to produce death is then one great enough to force a fixed minimum current through the body and will therefore vary both with the amount of contacting surface between the body and the live conductors as well as with the resistance of the portion of the body through which it flows. Furthermore, the resistance of the body will vary with the applied voltage; at low voltages it is as high as 35,000 ohms, while with voltages of the order of 100 the resistance drops to the neighborhood of 12,000 ohms. The reason for this is that the dry skin is a poor conductor of electricity normally, but under the higher voltage this resistance is broken down and the current readily enters the muscular tissues of the body which are by nature of their constituents good conductors with a low resistance.

This is further shown where moistened electrodes are used as in the case of electrocution. With a potential of 1,800 volts applied to the death-chair, the ammeter reads between 7 and 10 amperes or approximately a resistance of 200 ohms. This explains why a greater shock is felt when the hands are moist and why death may result from touching a live wire of even 100 volts potential, while in the bathtub with the body partially immersed in water.

It will be clear that the resistance of the body is also controlled somewhat by conditions. On a hot summer day, when covered with perspiration, the resistance is naturally lower than when the skin is dry.

Therefore, a voltage that might kill one in July might only result in a painful shock in February.

So far the results of poor contact with high voltage conductors has not been covered. Under these conditions the parts of the body in contact are usually badly burned, at times sufficient to demand amputation, while the person may survive. Another factor is the length of time the current flows through the body, for on this depends the amount of energy liberated in the body. Thus a current that may only be painful with severe muscular contractions may result seriously if the contact is maintained for any length of time. This consideration becomes important when it is realized



Fatality due to greater surface contact caused by immersion in water.

Lineman may complete a circuit across 30,000-volt transmission line with one to three ampere current; at 30,000 volts and 10,000 ohms the current would be 3 amperes.

An electric paradox. At a potential of nearly a million volts, the current passes over the outer surface of the body, and does not penetrate to the nerve and muscle centers.

that the common voltage of 550 is not great enough to cause instant death, but may paralyze the muscles and cause continuation of the contact that will result fatally. The person so held in the circuit is usually incapable of movement or speech and is helpless to summon aid and cannot detach himself.

It will be seen from the above that we have a number of interrelated factors to consider in determining the deadliness of a given voltage which might be summed up as follows:

- Voltage,
- Frequency,
- Resistance of body (skin wet or dry),
- Resistance of contact (small or large area),
- Time current is passing.

These factors are all more or less interdependent on one another.

The effect of the current in passing through the body is to produce muscular contraction and paralysis of the brain, as well as of the voluntary and involuntary organs. Should death not result there is likelihood of the functions of these organs being interfered with and a mental and physical deficiency or even total inability resulting. The current likewise decomposes the blood and causes an increase in the temperature of the body to as much as 128° F. or greater depending upon the current dissipated in the body.

NEWS OF THE PLANTS

The Detroit Steel Corporation, Detroit, Mich., recently organized with a capital of \$500,000, has completed plans and will soon break ground for the construction of its proposed new plant in the Oakwood section, where a tract of 12 acres of land has been acquired on the Fort Boulevard, vicinity of the River Rouge. The initial plant unit will consist of three main buildings, each one-story, 80x250 feet, 80x150 feet, and 50x150 feet, respectively. The plant will be devoted to the manufacture of strip steel, and the first noted building will be equipped as a cold rolling mill; the second structure will be used as a pickling room and storehouse, while the last noted building will be equipped for an annealing department. Contracts for certain machinery have been awarded, and orders will be placed for the remainder of the equipment at an early date. The works will include a number of traveling cranes and power house. It is proposed to develop an initial capacity of about 1500 tons of strip steel per month, and this output will be increased in the near future. The new company is headed by W. C. Schrage, connected with Craine & Schrage, 6189 Hamilton Avenue, Detroit, iron and steel merchants; Oscar Olson, formerly connected with the Columbia Steel Company, Elyria, Ohio, will be vice president and manager; Arthur Schrage, vice president of the Craine-Schrage Steel Company, will be secretary of the new organization; and Anthony Bodde, treasurer.

The Metal & Thermit Corporation, 120 Broadway, New York, has awarded a general contract to the Union Construction Company, Balfour Bldg., San Francisco Cal., for the initial unit of its proposed new rolling mill on Swift Street, South San Francisco, where a large tract of land recently was acquired. Orders for machinery will be placed in the near future and the plant pushed to completion. A number of mill buildings will be constructed with power house, estimated to cost close to \$2,000,000, fully equipped. E. W. Kardos, Swift Street, South San Francisco, is district manager. The Engineering Department of the company, 1427-29 Western Avenue, Pittsburgh, Pa.; Frank I. Ellis is in charge.

The Tacony Steel Company, Franklin Bank Bldg., Philadelphia, Pa., has preliminary plans under consideration for the complete rebuilding of the section of its plant at Milnor and Bleigh Streets, Ta-

cony, Philadelphia, recently destroyed by fire with loss estimated at close to \$100,000. A large part of the loss represents machinery and additional equipment will be required for replacement.

The Sharpville Furnace Company, Sharpville, Pa., is completing extension and improvement work at its plant, including the reconstruction and relining of the local blast furnace, increasing the capacity from 200 to 350 tons of pig iron per day. It is planned to place the unit in blast at an early date, as well as other sections of the plant, including a new ore trestle which has recently been completed.

The Manufacturers Iron & Steel Company, operating plants at New Brunswick, N. J., and Catasauqua, Pa., has disposed of the first noted works and will concentrate operations at the Pennsylvania plant. The machinery will be removed to that location, and plans are under consideration for an addition in the rolling mill to include the installation of additional equipment. The company will continue in operation its branch plant at Montreal, Que. Arrangements have been made for a change of name to the Bryden Neverslip Company and production will be centered on horse-shoes, including semi-finished material and finished products.

The Michigan Steel Corporation, Detroit, Mich., recently organized, is pushing construction on its new plant at Ecorse, Mich., about 9 miles from Detroit, to consist of a number of buildings for the manufacture of high-grade steel sheets. The works will comprise a number of one-story structures, with sheet mills, power house, etc., estimated to cost close to \$1,000,000, including machinery. To provide for initial operations the company is disposing of a bond issue of \$500,000, the proceeds to be used almost exclusively for working capital. Frederick B. Lovejoy is chairman of the board; George R. Fink, president; and F. H. Jones and J. M. Steele, vice presidents.

The British Empire Steel Corporation, Montreal, Que., has work under way on extensions and betterments for larger output and considerable increased efficiency at its Nova Scotia plant. The expansion will include additional equipment installation, as well as new power plant at New Waterford, N. S., for service at the mill. The improvement will cost close to \$50,000.

COMING MEETINGS

American Society for Testing Materials.—The twenty-sixth annual meeting of this society will be held on June 25 to June 29, at Chalfonte-Haddon Hall, Atlantic City, N. J., with a very full program of committee reports and papers on tests, fatigue, corrosion, preservatives, magnetic analysis and so forth of various materials. F. M. Farmer, chief engineer Electrical Testing Laboratories, New York City, will report as chairman of the committee on electrical insulating materials, and there will be papers on electrical insulating varnishes, electrical slate and other topics of interest to the electrical industry.

Public Utilities Advertising Association.—This association, organized last fall, will hold its first session in connection with the annual convention of the Associated Advertising Clubs of the World at Atlantic City, June to 7. The Public Utilities Advertising Association, which is rapidly growing, includes representatives of electric light and power, electric railway, gas and telephone companies in its membership.

National Electric Light Association—New York, June 4-8. M. H. Aylesworth, 29 West Thirty-ninth Street, New York.

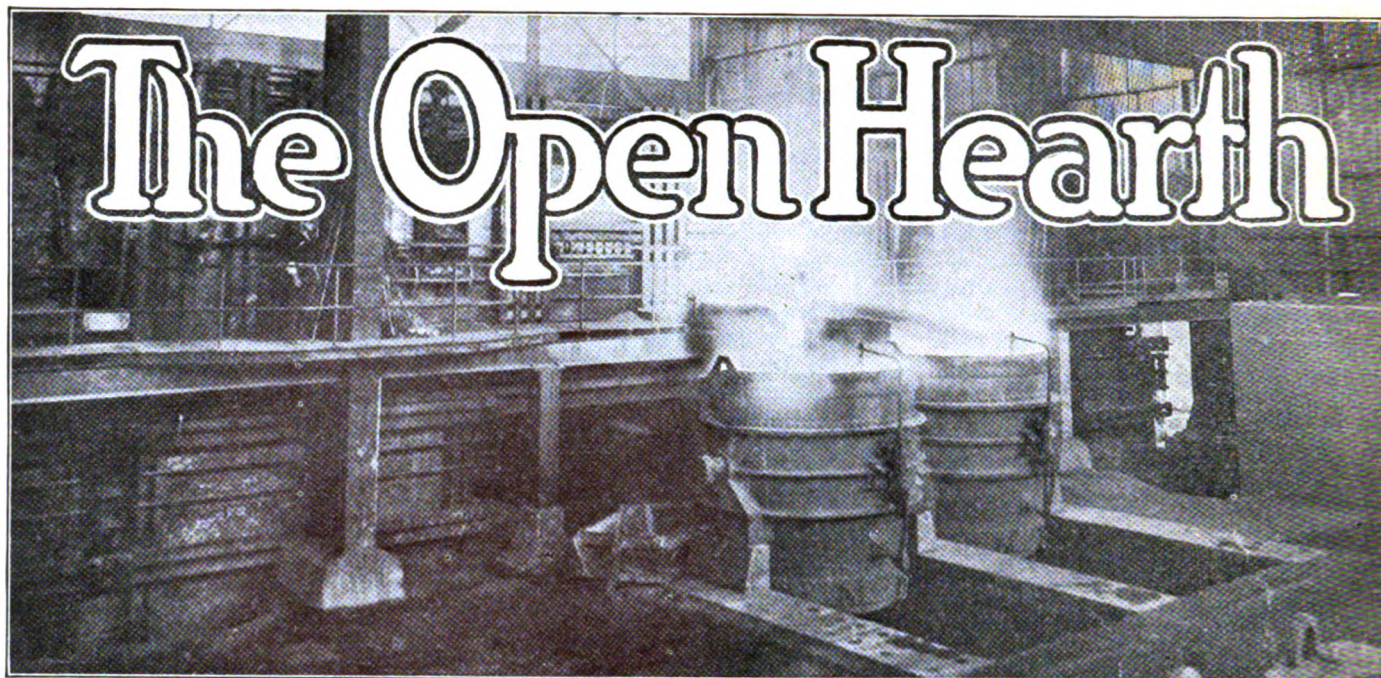
Society for the Promotion of Engineering Education—Ithaca, N. Y., June 20-22. F. L. Bishop, University of Pittsburgh.

American Institute of Electrical Engineers—Annual convention, Swampscott, Mass., June 25-29; Pacific coast convention, Del Monte, Cal., October 2-5. F. L. Hutchinson, 33 West Thirty-ninth Street, New York.

TRADE NOTES

Warren G. Drake, president of the Furnace Engineering Company of New York City, announces the organization of an associated company for the manufacture, sale and installation of a newly designed medium speed pulverizer. The development has been under the supervision of Dr. Paul M. Hirsch, whose varied experience with this type equipment is well known. Various materials besides fuels can be successfully pulverized.

The George J. Hagan Company and the Hagan Corporation announce their removal from the Peoples Bank Building to new and more spacious offices on the thirteenth floor of the Chamber of Commerce Building, Smithfield and Seventh Avenue, Pittsburgh, Pa.



Noah W. Elliott has been elected president of the Elliott-Blair Steel Company, New Castle, Pa., succeeding George D. Blair, who sold his interest in the company and retired from it April 30. Mr. Elliott has been engaged in the iron and steel business for more than 40 years, chiefly in the manufacture of cold rolled strip steel.

C. O. Sternagle, formerly with the American Bridge Company, Pittsburgh, for 11 years, and for the past 10 years with the Colonial Steel Company, seven years as branch manager in Chicago, has severed his connection with the latter company to engage in business for himself.

Banks Hudson, manager for several years at the Princess furnace in Virginia, has been appointed general manager for Joseph E. Thropp, Inc., with headquarters at Everett, Pa. He will have charge of operations at the Everett and Saxton blast furnaces, and of the mines, coke ovens, quarries, etc., located in Bedford County, Pa.

Harry W. Goddard, chairman of directors of the Wickwire Spencer Steel Corporation, sailed last Saturday for a three months' tour of Europe. His trip is primarily for rest, but incidentally to study conditions.

Ralph B. Rose, assistant general agent in charge of the bureau of bars and hoops, order and shipping department, Carnegie Steel Company, has resigned on account of ill health. Mr. Rose has been with Carnegie Steel Company for 22 years and previously for a number of years had been with Carbon Steel Company. He is retiring from active business for the purpose

of building up his health. His successor is Allen B. Carson.

Rawson Collier, until recently general sales manager of the Central Hudson Gas & Electric Company, has joined the organization of Dwight P. Robinson & Company, Inc., Engineers and Constructors, of New York. Mr. Collier was for five years a member of the firm of Collier & Brown, consulting engineers, Atlanta, leaving this firm to become connected with the Georgia Railway & Electric Company. Here his work covered 16 years, during which time he was connected with practically every department in the company. At the time of leaving he was general sales manager of the company. Mr. Collier is a graduate of the Massachusetts Institute of Technology, and for a number of years has been prominently identified with the work of the National Electric Light Association, the American Institute of Electrical Engineers, the American Gas Association and the Illuminating Engineering Society.

Dwight P. Robinson & Company, Inc., has started work on the construction of a central heating plant for the Allegheny County Steam Heating Company in the downtown district of Pittsburgh.

Craig Geddis has been appointed assistant sales manager of the Monongahela Tube Company Armco ingot iron department, Pittsburgh, Pa. The Monongahela Tube Company holds the license for the manufacture of pipe and boiler tubes from Armco ingot iron and for the past year Mr. Geddis has been developing and extending the sale of these goods—particularly among the oil refiners and producers.

Martin J. Conway resigned the position

of fuel engineer at the Midland, Pa., plant of the Crucible Steel Company of America and has accepted a similar position with the Wheeling Steel Corporation at the Steubenville, Ohio, plant.

Obituary

John Gilbert Ward, for many years treasurer of the Babcock & Wilcox Company, died April 22 at his home in New York City.

The death of James Smith, vice president and general manager of the New Process Copper Castings Company, resulted in several changes in the organization. William Smith, who recently resigned his position as general master mechanic of the Midvale Steel & Ordnance Company at Coatesville, Pa., becomes president; Mr. Mellor, formerly president, will become treasurer of the company, succeeding John Bramer, who will retain his position as secretary, and will also assume management of the foundry. Mr. Smith is widely known among blast furnace men throughout the country, having been actually engaged in the mills and blast furnace for the past 23 years. He was general master mechanic of the Jones & Laughlin Steel Company at their Eliza furnaces, resigning this position in 1913 to take a similar position with the Pennsylvania Steel Company at Steelton, Pa. With his knowledge of blast furnace work he is well fitted to direct the business of this company in the manufacture of copper castings for blast furnaces, and together with Mr. Bramer will give his attention to perfecting the several improvements by the late James Smith in the manufacture of these castings, particularly his more recent invention for casting bosh-plates containing no anchors.

WITH THE EQUIPMENT MANUFACTURERS

An Important Advance in Pump Valves

Users and prospective users of pumps will be interested to know that some decidedly valuable improvements in pump valve construction are now announced by the Worthington Pump & Machinery Corporation of New York. An entirely different form of valve has been perfected which when applied to service



FIG. 1

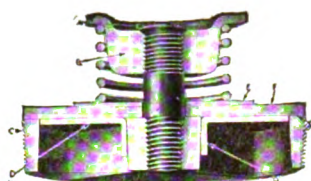


FIG. 2

conditions that have been difficult for the older standard valves by causing them to cut and to leak, will eliminate both. It therefore increases the average pump efficiency; decreases the cost of pumping; and continually maintains the capacity of the pump at its maximum point.

Every student of pumps knows of the vast money loss taking place every day due to leakage through the ordinary pump valves when used for severe service conditions. This has led one prominent manufacturer who makes pump valve rubbers as well as other mechanical rubber goods to say in one of his pieces of advertising literature:

"It is a fact that there is more real economy—more actual saving of money—in the use of a first quality pump valve than in any other one item in the entire mechanical rubber line. We are absolutely sure that this is true."

After many years of building and operating pumps the Worthington engineers have found that the principal cause of leakage is traceable to the excessive wear on the rubber, which while negligible in some cases, is often quite bad. The photograph of a hard rubber valve after three months of a particularly hard service will show cracks and cuts caused by the valve seat and by the radiating ribs plainly visible. A medium rubber valve, also after three months of unusually difficult service, will look the same. It is plain that the only way to positively prevent leakage with such ordinary valves in this condition is to remove and replace them with new valves.

To overcome this rapid and costly wearing, cutting, and cracking action, the Worthington engineers have evolved the new and novel type of valve shown in Fig. 2, known as the Worthington "Seal" valve for use when the conditions are too hard for the ordinary form of valves now in standard use.

This new "Seal" valve assures absolute tightness when closed because, as will be noted, the rubber used is "flexible" and will always seat perfectly both at the hub and outer rim, its inner and outer seats, and so keep tight. Age and continuous usage do not cut grooves or cause cracks as demonstrated for one year in this new type of valve. At the end of the year there was no visible wear; there was no leakage; renewal was of course unnecessary; and there was no cost for repairs.

The ingenuity and simplicity of this valve are evident upon inspecting Fig. 2. There are no screws, no bolts, no rubber rings, no nuts, no bushings, no rotating elements. The special new feature that makes this valve so good for hard service is the so-called "bottom plate." This is in effect a middle seat for the rubber valve proper. When the valve is closed this middle seat carries the entire load and prevents the rubber seal from cutting on the seats or ribs. This bottom plate moves up and down with the rubber, and so not only acts as a middle seat, but this middle seat is movable with the rubber and helps to keep the rubber valve in shape even when open. Thus all mechanical functions requiring strength and wear resistance are cared for by metal parts. The flexible rubber acts only as a seal against leakage. It will be noticed that even the top of the rubber seal is protected by a thin "backing plate" which keeps the rubber seal flat and prevents any possibility of wear from contact with the spring.

All moving parts are light but amply rigid. The lightness assures a smooth, quiet running pump. The rigidity prevents the distortion that results in leakage.

It is not anticipated that repairs or replacements will be often required, but the construction makes this easy when it does become necessary, and the cost of any possible repairs will be low because of the simplicity and inexpensiveness of all parts.

This valve is especially suitable for severe and unusual conditions and of course is available even for ordinary pumping conditions.

New Improved Electric Soldering Iron

The American Electrical Heater Company, Detroit, Mich., four-page full size folder is an excellent exposition of the uses and value of their recently designed and improved electric soldering iron, which carries their well known trademark, "American Beauty."

For light to medium-heavy soldering operations these irons are ideal. The fact that they are entirely free from hazards caused by flame, combustion, vitiation of the atmosphere, explosions, injuries to the eyes from constantly facing a flame, makes

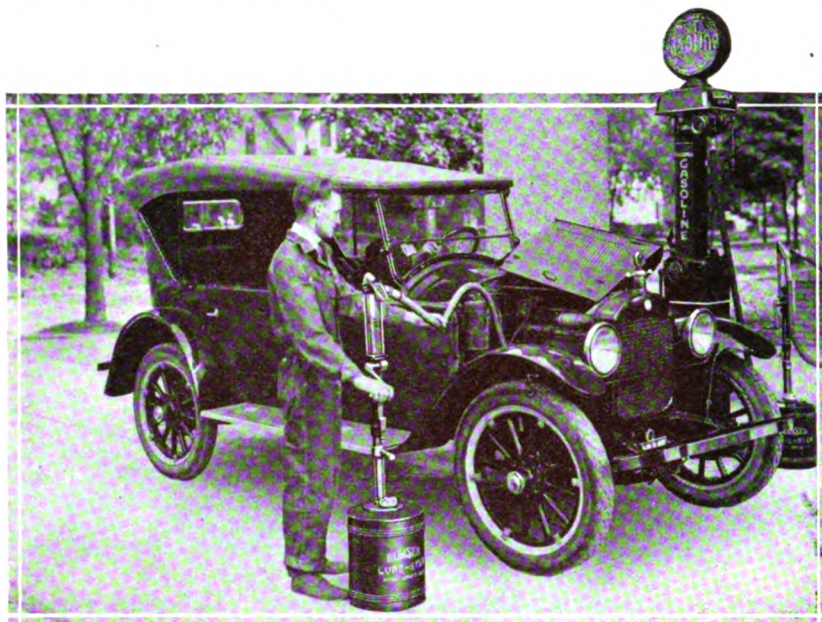


their use commendable. For the man who wishes to 'tinker' around home there is no end of uses to which these soldering irons can be adapted; and for use in the garage, where gasoline must be considered a hazard, they are almost indispensable. Nor are these reasons alone to be considered, for there are so many additional points in their favor that one has but to comprehend them to become thoroughly convinced that they are nearly indispensable where one has soldering operations to perform.

The fact that many, many thousands of "American Beauty" electric soldering irons are in daily use wherever electricity is known, is ample proof that these irons are all that could be wished for. Their superiority over ordinary soldering tools is the result of 28 years' experience in making highest grade electrically heated devices.

The Bowser "Lube-ster"

S. F. Bowser & Co., Inc., Fort Wayne, Ind., have just issued a 12-page bulletin describing the "Lube-ster," a portable oil-measuring and filling device for garages.



This attractive device is of increasing interest to steel plants, whose transportation problem has become more and more a trucking problem. Trucks require the best of lubrication, which unfortunately is not always remembered. The "Lube-ster" refuses to let the driver or mechanic forget; standing beside the gas pump, it insists upon being used at the same time that the gas tank is being filled. The operation, as shown in the cut, is identical—no more sloppy metal measures—a visible oil glass—an automatic pump and a hose reaching any oil reservoir.

Special Turbines for Extreme Temperatures

There are now available turbine frames designed especially for use with very high temperature steam. The casing and governor valve body are of cast steel. The governor valve and

seats, hand valves and seats, jets and some other parts are of monel. A standard Terry wheel is used, which, including the buckets, is machined from a single steel forging. Carbon ring glands with Monel Garter springs are used.

The shaft is carried in two heavy pedestal bearings resting directly on the base plate. The casing is also supported from circular lugs on these pedestals. With this type of construction, maintained shaft alignment is assured, regardless of the expansion and contraction of the casing, or any distortion which may take place in it. This pedestal bearing, suspended casing, construction has been in use for about six years with initial steam temperatures of about 700 deg. F., and it maintains alignment even with the cast-iron casings which are in use on the turbines to which we refer.

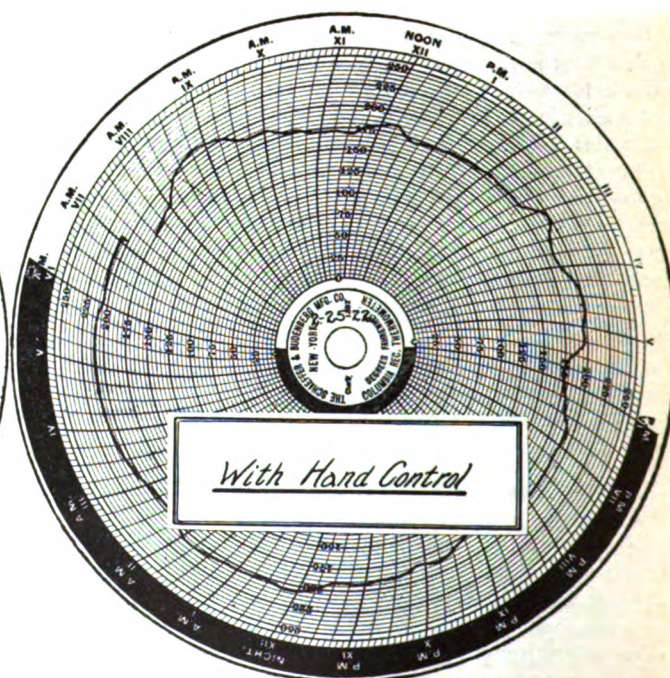
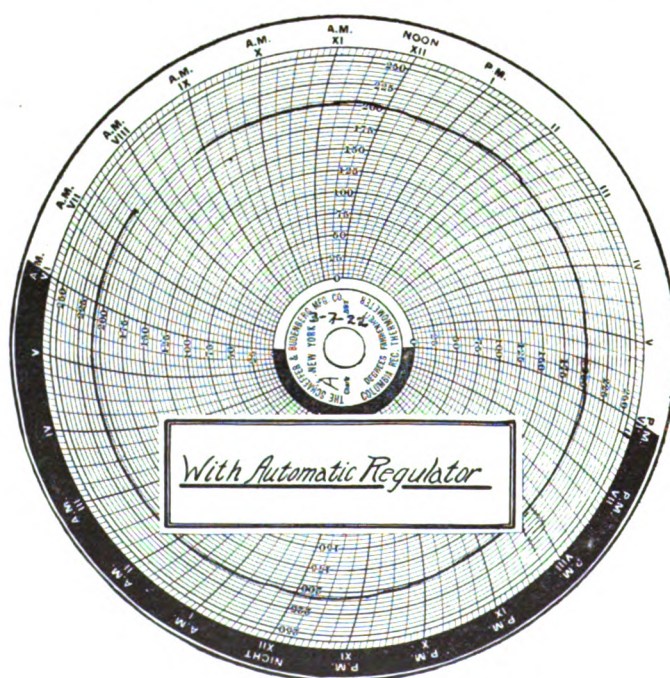
Governor Thrust Bearings.

There has been developed an improved governor thrust bearing which is so constructed as to minimize the vibration which is so frequently present at this point. The casing of the thrust bearing is stationary and completely closes the end of the governor housing, protecting the governor from dirt and facilitating the lubrication of the working parts of the governor.

Heat Balance Control.

Special attention is called to the improved system of controlling the maintenance of good station heat balance. As usually applied, a thermostat is installed in the feed-water heater and a hydraulic relay, actuated by the thermostat, then adjusts the speed settling of the turbine governor so it will take just enough load to give exhaust steam to heat the feed water to the desired point, and no more. In the case of duplex drives, the turbine may be made of sufficient capacity so that at times of maximum demand for exhaust steam the turbine will drive the motor as an induction generator, feeding current back to the a.c. mains, in addition to driving the auxiliary.

An important feature of this control is that in the event of the failure of the electric drive with which the turbine works in conjunction, the control system automatically gives preference to continuity of operation regardless of the feed water temperature. In other words, this control system does not interfere with the safety feature of duplex drive.



TRADE NOTES

The Gary Tube Company recently placed an order with the Chapman Engineering Company of Mt. Vernon, Ohio, for 28 Chapman automatic gas producers. These are for the new tube plant which this company is building at Gary, Ind. This new plant will be equipped with both butt weld and lap weld furnaces. The most modern machinery and construction are being used throughout to make it the most up-to-date plant of its kind in the country.

Notice has recently been received of the removal of the Link-Belt Company's Pittsburgh branch office from their old quarters at 1501 Park Building to their new and more commodious offices at 335 Fifth Avenue. T. F. Webster, manager of the Pittsburgh office, says that larger space and more convenient location were imperative because of the extraordinary volume of business transacted during the past year and which promises to remain in full swing at least for the coming fiscal year.

Two Brassert washers have been ordered by the McKinney Steel Company, Cleveland, Ohio, of Freyn, Brassert & Company, Chicago. These washers are being installed at the River blast furnace plant of the McKinney Steel Company.

The Westinghouse Electric & Manufacturing Company has received orders for the majority of the new equipment to be installed at the Clairton works of the Carnegie Steel Company. This equipment includes motors, motor generator sets, transformers, switchboard, and other apparatus for this installation.

In addition to the other contracts that it has awarded to the U. G. I. Contracting Company of Philadelphia, the Kings County Lighting Company, of Brooklyn, N. Y., has authorized the former company to install a complete booster plant at Sixty-fifth Street and Ninth Avenue, Brooklyn. This plant will consist of two 200-hp. oil fired boilers and two engine driven boosters, each having capacity of 300,000 cu. ft. per hour, and appropriate surface condensers and other auxiliary equipment. The boilers and other machinery will be properly housed in buildings that will be erected as part of the contract.

The U. G. I. Contracting Company of Philadelphia has lately been awarded contract for the installation of an 11-inch cone top carburetted water gas apparatus, together with a vertical waste heat boiler and its new Model "B" automatic control at the Flint, Mich., plant of the Michigan Light Company.

The U. G. I. Contracting Company, distribution department, is engaged in laying a 20-inch gas main under the Schuylkill River in Philadelphia. This work is necessitated because of the building of a new bascule type bridge at Passyunk Avenue.

The London Steam Turbine Company of Troy, N. Y.; Drake Non-Clinkering Furnace Block Company; Furnace Engineering Company of New York City; Allen-Sherman-Hoff Company of Philadelphia, and Wm. Reed Engineering Company will be represented in the Pittsburgh territory by Alfred Campbell, Inc., Frick Building Annex. Mr. Campbell will continue to personally represent the Mr. H. Detrick Company of Chicago.

The Westinghouse Electric & Manufacturing Company has received an order from the American Rolling Mill Company for electrical equipment amounting to about \$70,000. The order includes mill motors, control apparatus, and a switchboard.

The Inland Steel Company has purchased about \$375,000 worth of electrical equipment from the Westinghouse Electric & Manufacturing Company. The apparatus will be used in connection with the enlargement of the steel company's mills.

The Koppers Company has recently opened up a district office at 1709 Peoples Gas Building, Chicago, Ill., to take care of its rapidly growing business in that section of the country. Angus McArthur, formerly superintendent of the coke plant, Chicago By-Product Coke Company, Chicago, has been appointed district engineer in charge.

P. L. Howenstine has been elected to the board of directors of the Superior Sheet Steel Company, Canton, Ohio, at the annual meeting of the company to succeed the late Harry S. Renkert. At the same time he was made treasurer of the company. Mr. Howenstine was one of the original incorporators of the company and held the positions of assistant treasurer and purchasing agent.

Uehling Instrument Company, Paterson, N. J., manufacturers of CO₂ recorders and draft and vacuum gauges, have just made two important agency appointments, namely, Amsler-Morton Company, Fulton Bldg., Pittsburgh, Pa., for Western Pennsylvania, and John A. MacDowell, 2039 Railway Exchange Building, St. Louis, Mo., for Eastern Missouri and Southern Illinois. H. R. N. Johnson, who formerly represented the Uehling Instrument Company in Minnesota and the Dakotas, has joined the W. P. Nevins Company, 120 South Ninth Street, Minneapolis, Minn., which company is now the official Uehling representative in the territory mentioned.

The U. G. I. Contracting Company of Philadelphia has lately received contract from the Syracuse, N. Y., Lighting Company which will include the erection of a 2300-volt, 6-cycle switch house, together with cable volts, switchboard, reactance circuit breakers, etc. Included in the contract is the furnishing and erecting of a 2300-volt, 60-cycle generator bus extension, also additions to the switching equipment for synchronous condenser.

The Electric Storage Battery Company has recently announced a plan whereby their employees can become stockholders in the company, under favorable terms. This company is well known as manufacturers of the Exide battery. Recently a pension fund was created and a fully equipped clubhouse for recreation purposes was opened.

Link Belt Company's offices, formerly in the Park Building, have been moved to larger and more convenient space at 335 Fifth Avenue. At present good business bids fair to continue indefinitely. The move was necessary to provide proper space for handling affairs of this branch.

BOOK REVIEW

The Engineering Index

The twenty-first volume of The Engineering Index, the fourth one to be issued by the American Society of Mechanical Engineers, excels its predecessors, it is believed, in the care exercised in the selection, preparation, and arrangement of the items.

Some 1,300 periodicals, reports, and other publications regularly received during the year by the Engineering Societies Library, New York, have been reviewed, and from over 600 of these, listed on pages vii-xiv, the articles to be indexed have been selected. At least 20 per cent of these periodicals are printed in Great Britain and her possessions, and approximately 30 per cent are representative publications of Belgium, France, Germany, Italy, Spain, South America, and other foreign countries. For two reasons the items have been made unusually concise. First, it is believed that the value of the Index increases with the number of references it contains; and secondly, this volume indexes not only the 1922 periodicals received during the calendar year, but also 1921 publications which came in too late to be reviewed in the 1921 Index, and all late 1922 publications received previous to February 15, 1923. The book, therefore, contains a larger number of references than ever before, but by virtue of conciseness, its size has not been unduly increased.

Frequent users of the book will find that the classification and the system of cross-indexing have been perfected. The extended list of references to bibliographies is an instance of the attention which has been given to details.

For references to other articles appearing since the close of 1922, readers are directed to The Engineering Index section of the Society's monthly publication, *Mechanical Engineering*, in which perhaps half of the items included in this volume appeared during 1922, and to *The Engineering Journal*, the monthly publication of the Engineering Institute of Canada.

Some Pointers on By-Product Coke Oven Operations

Desulphurization of Coke by Air

By ALFRED R. POWELL

Associate Chemist, Pittsburgh Experiment Station, U. S. Bureau of Mines

In another paper* the writer has described an investigation in which the forms of sulphur in coke were determined and described. Since this oxidation of the ferrous sulphide took place so easily, an investigation was undertaken to determine whether this property could not be taken advantage of in some industrial process for the desulphurization of coke.

The desulphurization of coke by roasting in air is not a new idea, but dates back to the earliest days of coke manufacture. In 1871, Philippart† published the results of some work done by him on the desulphurization of coke by air, as well as a review of the results of earlier investigators. In these earlier experiments, nothing was known of the forms in which the sulphur existed in the coke, while the temperature measurements were only approximate, so that altogether the results were not very conclusive nor complete. The desulphurization figures given by these early investigators generally showed a low efficiency for the process, but some extraordinary results were claimed by certain inventors. In the light of our new knowledge concerning the coke sulphur, it seemed to be important enough to warrant investigation.

One of the first factors to be determined in this investigation was the optimum temperature for the oxidation of the ferrous sulphide in the coke. From general considerations it might be assumed that the higher the temperature the faster would be the oxidation of the ferrous sulphide, and yet on the other hand the coke itself would oxidize faster at the higher temperatures. It was, therefore, necessary to determine a mean temperature that would best satisfy both conditions.

A series of runs at different temperatures was made, in which powdered metallurgical coke was placed in a tube heated to the desired temperature, and a slow current of air was passed over it. Then analysis of the residue for ferrous sulphide showed the thoroughness of the oxidation, and the loss in weight of the sample showed the relative coke loss at different temperatures. At 300 deg. C. the oxidation of ferrous sulphide proceeded rather slowly, and there was no loss of coke. At 400 deg. the oxidation took place much more quickly, and

*"The Forms of Sulphur in Coke," Jour. Am. Chem. Soc., vol. 45, 1923, pp. 1-15.
†Philippart, M. A., Rev. Univ. des Mines, vol. 28, 1871, pp. 261-318.

DESULPHURIZATION BY AIR OF COKE NO. 1

Run No.	Original	1	2	5
Temperature, deg. C.....	500	650	500	500
Roasting time, minutes.....	30	30	210	210
Vacuum time, minutes.....	10	10	none	none
Sulphur evolved as SO ₂ , per cent of coke.....	0.19	0.23	0.46	0.46
Coke loss, per cent.....	none	1	1	1
Sulphur as solid solution, per cent.....	1.90	1.90	1.90	1.90
Sulphur as ferrous sulphide, per cent.....	0.58	0.24	0.24	0.11
Sulphur as free sulphur, per cent.....	0.62	0.50	0.38	0.39
Sulphur as sulphate, per cent.....	0.10	0.13	0.10	0.31
Total sulphur, per cent.....	3.20	2.77	2.62	2.71

DESULPHURIZATION BY AIR OF COKE NO. 2

Run No.	Original	9	10	11
Temperature, deg. C.....	500	500	500	500
Roasting time, minutes.....	30	...	...	...
Vacuum time, minutes.....	10	...	...	...
Sulphur evolved as SO ₂ , per cent of coke.....	0.08	0.08	0.14	0.14
Coke loss, per cent.....	none	none	none	none
Sulphur as solid solution, per cent.....	0.84	0.84	0.84	0.84
Sulphur as ferrous sulphide, per cent.....	0.26	0.16	0.12	0.10
Sulphur as free sulphur, per cent.....	0.19	0.23	0.18	0.15
Sulphur as sulphate, per cent.....	0.02	0.04	0.06	0.06
Total sulphur, per cent.....	1.31	1.27	1.20	1.15

still there was no appreciable loss of coke. At 500 deg. the oxidation of the ferrous sulphide was complete at the end of a few minutes, and the coke loss was very small, being under 1 per cent. At 600 deg. and higher a very noticeable coke loss took place, and the oxidation of the ferrous sulphide was slower, if anything, than at 500 deg., since the oxygen was consumed in the combustion of the coke.

These experiments showed that 500 deg. was the best temperature for the oxidation of the ferrous sulphide when the relative speeds of oxidation of the ferrous sulphide and the coke itself were considered. For this reason the temperature used in the treatment of the chunk coke was 500 deg., although several runs were made at temperatures as high as 650 deg. for reasons that will be described later.

Any process designed to secure the desulphurization of coke by air must involve two stages at least. The first stage consists of the oxidation of the ferrous sulphide of the coke to form iron oxide and free sulphur.

The second stage of the process consists in the removal of the free sulphur formed in the oxidation, and which has been absorbed on the surfaces of the coke. Three different methods for the removal of this sulphur from the coke were tried in this investigation.

Since metallurgical coke must be kept in the chunk form in which it is made, all of the desulphurization tests were performed on coke which ranged from 2 to 3 inches in diameter. By doing this, results could be obtained which would be comparable to large-scale practice, while tests on powdered coke would have little real meaning.

One rather serious source of error was present in these experiments, and to eliminate it entirely seemed impossible. This was the fact that one chunk of coke had to be taken as representative of the original coke, while several other chunks from the same batch were taken for the test.

Two different cokes were tested in this investigation. No. 1 was a high-sulphur coke manufactured in a vertical retort. In this coke the solid-solution form of sulphur predominated, so that little desulphurization was possible. No. 2 was a coke made from Illinois coal, and was of such a type that proper desulphurization could have made it available for blast furnace coke. The results of the different tests are given in the accompanying table.

SUMMARY AND CONCLUSIONS

It is possible to draw the following conclusions from this investigation of the desulphurizing effect of air on coke:

1. At temperatures near 500 deg. C., it is possible to oxidize the larger part of the ferrous sulphide in coke to iron oxide and free sulphur, without causing any appreciable oxidation of the coke itself.

2. The free sulphur produced as just described is retained in the coke in an absorbed form. It has been found impossible to remove this from the coke completely, and even part removal has been very difficult.

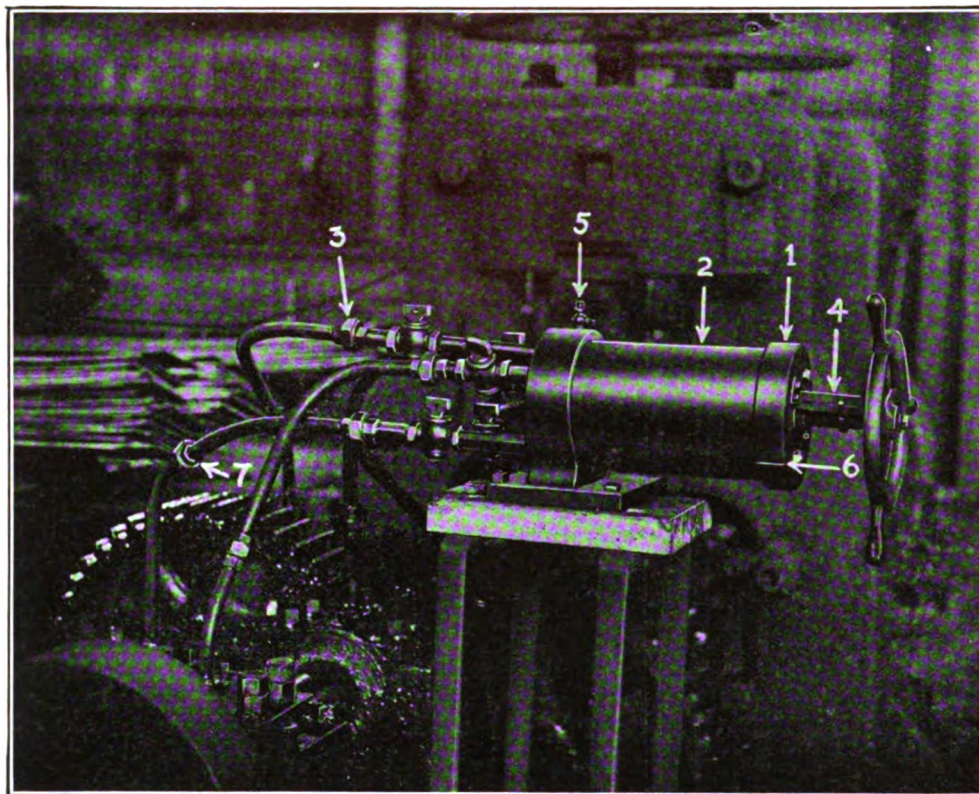
3. This investigation has indicated that the industrial desulphurization of coke by air treatment is not practical as far as the methods which have been tested would apply. The chief difficulty in the application of the process lies in the tenacity with which the free sulphur is retained in the coke.

Figure shown is a chart from the recording thermometer in the feed water heater at the plant of the Sioux City Gas & Electric Company, Sioux City, Iowa. This plant uses a Terry heat balance control on a 75-kw. duplex exciter. A change of 2 deg. F. in feed water temperature will change the load carried by the turbine. At times of maximum station load the induction motor is driven as a generator to some extent, although the maximum benefit is not obtained as the turbine was not built with this in view.

This control is now offered for both new and existing duplex drives; wherever installed, the operating value of such units is greatly increased.

The Keystone Manifold Safety Lubricator

"Eliminate Risk and Waste," is the title of an interesting booklet issued by the Keystone Lubricating Company of Phila-



No need for neglected bearings due to inconvenience and hazardous conditions.

delphia, Pa., describing the Keystone Manifold Safety Lubricator (shown in accompanying illustration).

The Keystone Manifold Safety Lubricator presents a method of applying Keystone grease under high pressure with pipe line distributions to more than one bearing. It accomplishes this result without risk to the operator or waste of grease. Bearings that are difficult of access due to small clearances between working parts, heat and other unfavorable conditions, are made easy to reach by this medium of lubrication, thus insuring the proper lubrication of bearings that otherwise might be neglected because of inconvenience and hazardous conditions.

New Rotary Air Compressor

Few parts, practically isothermal compression and smooth running are features claimed for the rotary air compressor illustrated, a development of the Hill Engineering Company, Inc., 42 Broadway, New York.

Two simple rotors in a housing are the chief components of the machine. An analysis of the principles of design incorporated

in the rotors is said to involve a field of geometry as yet substantially unexplored, and an explanation of the principles is promised in the near future.

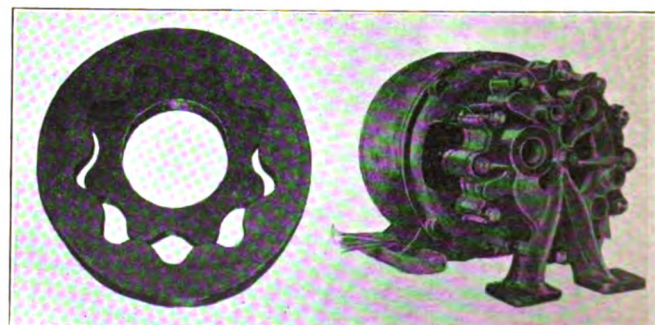
The rotors are within a housing and are driven directly by the motor shaft. Two rotors are employed, one within the other as shown. They have lobes and roll together, opening chambers to take in air and closing them to discharge it. The chambers are kept air tight automatically in order that there will be no air leak or slip between the rotors in case of wear. The two rotors run at speeds of eight to nine, a difference of one, and for nine turns of the driving shaft they turn on each other but once. This, it is pointed out, makes high speeds practicable. The rotors run between films of lubricant and the films are found to prevent air leakage over the sides of the rotors.

Because of having nine chambers, there is compression in stages, for the higher pressures four stages, each successive chamber between intake and discharge ports having a higher pressure than the one before it. The liquid flowing through the rotors cools the air compression by direct contact, which is said to make intercooling between the stages unnecessary, the liquid absorbing the heat of compression. After discharge, the air and liquid are separated in a separator provided, the liquid being cooled and returned under high pressure to repeat its function. For 150-lb. pressure, the discharge temperature is said to be not much over 100 deg. F. It is further claimed that by this process the air may be washed.

Elimination of clearance in the rotor chambers is emphasized, thus favoring a high volumetric efficiency; low compression temperatures and the four stages of compression in one mechanical movement are offered as claims for high mechanical efficiency and small power consumption.

In a test of one machine, 375-lb. air pressure is said to have been attained without pushing. The machine is available in capacities up to 7½ cu. ft. at 125 lbs. It was shown at the International Exposition of Inventions and Investments, held in New York, Feb. 16 to 23.

On the right of the figure shown below is shown the rotary air compressor with its driving motor, while on the left the internal arrangement of rotors is pictured. The simplicity of the compressor, which consists of merely two simple rotors in a housing, is indicated by the figure.



Rotors

Rotary Compressor

JUN 10 1923
In July—A VISIT TO BETHLEHEM STEEL—Part II.

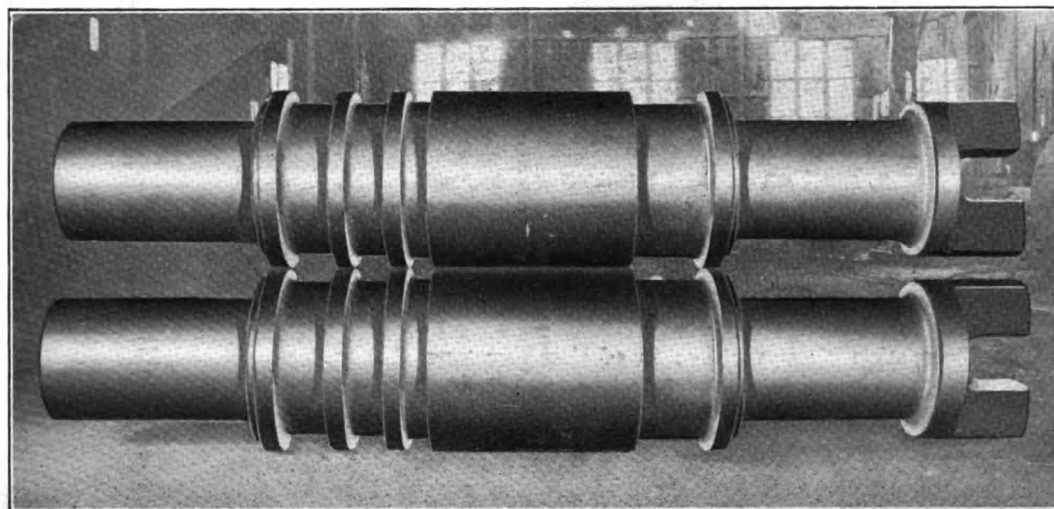
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